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INDEX TO VOL. XVIII.

A

Abercromby, R., Sunrise Shadows in Ceylon, 43.
Accumulators (*see* BATTERIES, SECONDARY).
Acheson's Duplex Wire, 330.
Alloys, Conductivity of Some, by C. L. Weber, 109.
Allpress, V. S., Primary Batteries for Lighting, 33.
Alternating Currents for Determining the Conductivity of Electrolytes, by T. C. Fitzpatrick, 400.
Alternating Currents for Measuring Liquid Resistances, by Bouty and Foussereau, 105.
Aluminium, Electro-deposition of, 305.
Aluminium, Rubies obtained from the Smelting of, 459.
American Bell Telephone Company, Apparatus made by, 233.
Ammeters and Switches, the E.P.S., 467.
Anderson, Sir J., Cables and War, 191.
Anglo-American Brush Company *v.* Crompton, 90.
Arnoux, R., Dynamo Design, 110.
Arrhenius, S., Action of Electrolysis on an Electrolyte, 105
Arrhenius, S., Conductivity of Aqueous Acid Solutions, 217.
Atlantic Cables, Proposed (Leading Article), 59.
Ayrton and Perry, Magnetic Resistance, 442.
Ayrton and Perry, Relation of Capacity to Thickness of Dielectric, 442.

B

Barrett, J., his Method of duplexing Telephone Circuits, 18.
Batteries, Primary:—
Bidwell's Lead Cell, 132.
for Lighting, by V. S. Allpress, 33.
Method of Determining Resistance of, 426.
Upward's, 348.
by S. F. Walker, 243, 264.
Walker's Cell, 213.
Batteries, Secondary:—
Brush and Faure's Patent in the United States, 145.
for Electric Lighting, by D. G. FitzGerald, 397, 414, 442, 457.
Kent's Automatic Switch for, 479.
Swinburne's Experiments on, 153, 173.
Union Company's Cell, 190.
Bells, Electric, Moseley's Improvements, 85, 152.
Bentley and Knight's Electric Railway, 240.
Bernstein's System of Lighting, Improvements in, 202.
Bidwell, S., Diathermancy and Electrolytic Conductivity, 35.
Bidwell, S., Resistance of Suspended Wires, 441.
Bidwell, S., Self-induction, 441.
Bidwell's Lead Battery, 132.
Bills Proposed in Session, 1887, 89.
Bolton, Sir F., Death of, 190, 332.
Books, Reviews of (*see* REVIEWS).
Bosanquet, R. H. M., Determining Coefficients of Mutual Induction, 381.
Bosanquet, R. H. M., Electro-magnets—Tension of Lines of Force, 83.
Bosanquet, R. H. M., Permanent Magnets—Magnetic Decay, 145.
Bosanquet, R. H. M., Magnetisation, Sequences of Reversals, 551.
Bouty, E., Conductivity of Potassic Chloride, 311.
Bouty, E., Conductivity of Weak Salt Solutions, 62, 81.
Bouty, E., Electrolytic Conductivity, 34, 61.
Bouty, E., Mechanical and Thermal Effects of Electrolysis, 105.
Bouty and Foussereau, Alternating Currents for Measuring Liquid Resistances, 105.
Boys, C. V., Fibres, 489.
Bright, Sir C., Presidential Address to S. T. E. and E., 219, 245.
Brighton Electric Railway, 260, 269.
British Association (*see* SOCIETIES' MEETINGS).
Bruger, T., Solenoids and Iron Cores, 147.
Brush Company's Portable Electric Light Apparatus, 371.
Brush and Victoria Dynamos, 198, 199.
Burglar Alarm, Taussig's, 441.
Business Notices, 24, 92, 204 248, 406, 428, 450 (*see also* CITY NOTES).

C

Cables:—
for Alternating Currents, 543.
to Australia (criticisms by *Imperial Federation*), 374.
or Cruisers, 79, 191.
and The Empire (Leading Article), 544.
Faults in, by A. E. Kennelly, 468, 486, 506, 530.
France and Ocean Cables, 328, 334.
to New Zealand, 39, 57.
proposed Atlantic (Leading Article), 59.
and Submarine Telegraphy, 456, 482, 497, 520.
Callow *v.* Young, 68.
Calorific Equivalents, Professor Thomson's, criticised by D. G. FitzGerald, 457.
Calorific Values and E.M.F.'s, by D. G. FitzGerald, 498.
Capacity, its Relation to Thickness of Dielectric, by Professors Ayrton and Perry, 442.
Capital and Dividend, Reduction of (Leading Article), 80.
Cauchy's Theory of Light, by J. Walker, 132.
Central Institution and Finsbury College (Leading Article), 480.
Central Stations, Hourly Variations in Current from, 123.
Central Stations, Plans for Installing, by A. F. Upton, 427.
Chamberlain-Hookham Dynamo, 304.
Champain, Col. Sir J. B., Death of, 283, 332.
Chauvin, M., Magnetic Rotary Power of Crystals, 310.
Cherrill, N. K., Varnishing Incandescent Lamps, 484.
City Notes, 318, 340, 362, 384, 406, 428, 450, 472, 490, 512, 534, 555, 574.
Clausius, —., Relation of Electricity and Heat, 110.
Clayden, A. W., Internal Capacity of Thermometers, 43.
Cocks *v.* Great Western Railway, 44, 67, 449, 500.
Colonial Exhibition, Tests of Engines at, 52.
Commutator for Converting Continuous into Alternating Currents, Pfaunkuche's, 523.

COMPANIES' MEETINGS, REPORTS, &c.:—
Anglo-American Brush, 339, 359.
Anglo-American Telegraph, 266, 315.
Blackpool Tramway, 68, 92.
Brazilian Submarine, 574.
Cuba Submarine, 274, 295.
Direct Spanish Telegraph, 449, 470.
Direct United States Cable, 226, 271.
Eastern Extension Telegraph, 534, 552.
Eastern Telegraph, 226, 247, 270.
Electrical Power Storage, 450, 470.
Equitable Telephone, 555.
German Union, 428, 449.
Great Northern of Copenhagen, 573.
Gülcher Electric Light, 156.
India Rubber, &c., 274, 318, 358.
Indo-European Telegraph, 534, 551.
Maxim-Weston, 404.
Montevidean Telegraph, 449.
New Telephone, 179, 274.
Oriental Telephone, 489, 554.
Pilsen-Joel, 46, 180.
Reuter's Telegram, 534, 554.
River Plate Telephone, 90, 136, 532.
Simplex Syndicate, 179.
Submarine Cables Trust, 574.
Submarine Telegraph, 338.
Swan United, 340, 360.
Telegraph Construction, 383.
Telephone Company of Egypt, 383.

COMPANIES' MEETINGS (*continued*):
Telephone of Ireland, 490, 533.
United River Plate Telephone, 532.
West Coast of America Telegraph, 455, 573.
West India Telegraph, 24, 44.
Western and Brazilian, 384, 403.
Western Counties Telephone, 512.

Companies Formed during 1886, 201.
Companies, New, 114, 158, 472, 490, 555.
Concert given by Eastern Telegraph Company's Staff, 178.
Conductivity of Alloys, by C. L. Weber, 109.
Conductivity of Aqueous Acid Solutions, by S. Arrhenius, 217.
Conductivity of Dilute Solutions, by F. Kohlrausch, 16.
Conductivity of Electrolytes, Alternate Currents for Determining, by T. C. Fitzpatrick, 400.
Conductivity, Electrolytic, by S. Bidwell, 35.
Conductivity, Electrolytic, by Professor Bouty, 34, 61.
Conductivity of Potassic Chloride, by E. Bouty, 311.
Conductivity of Weak Salt Solutions, by E. Bouty, 62, 81.
Conduction, Electric, by Dr. Hopkinson, 17.
Conductors, Compound, Self-Induction of, by Lord Rayleigh, 170, 222, 240.
Contemporary Progress, by G. W. von Tunzelmann:—
Bouty, Conductivity of Potassic Chloride, 311.
Chauvin, Magnetic Rotary Power of Crystals, 310.
Cornu, The form of the Wave Surface of Light in an Isotropic Medium in a Magnetic Field, also, Existence of a Special Double Refraction in a Direction Normal to the Lines of Force, 107.
Cornu and Potier, Verification of Verdet's Law, 107.
Streintz and Aulinger, Polarisation of Lead, 309.
Weber, C. L., Conductivity of some Alloys, 109.
Wild, Terrestrial Magnetic Disturbances and Solar Phenomena, 310.
Copper Disc Galvanometer for Alternate Currents, 561.
Copper Wires, Resistance of Suspended, by S. Bidwell, 441.

Correspondence:—

Accumulators, *see* BATTERIES, SECONDARY.
Almack, E., Electioneering and Scientific Societies, 103.
Alternating Currents, Novel Phenomena, 546.
Aluminium, How to Solder it, 285.
Anode and Cathode, 462.
Armature Cores, Stationary, 307.
Armature Winding, 100.
Babbage's Notation, 147.
Batteries, Primary:—
and Electric Lighting, 285.
Pollack's Cell, 327, 351.
Batteries, Secondary:—
Automatic Switches for, 502, 523.
Gudot's Cell, 14, 38.
Union Company's Cell, 213, 239, 261, 417, 439.
Mercury Contacts and Celluloid for, 461, 482, 501.
Theory of 481, 501, 521, 545.
Bernstein, A., Secondary Generators, 60.
Blathy, O. T., Heating of Cores, 327.
Bosanquet, R. H. M., Characteristics of Dynamos and Notation, 37, 78, 100, 125.
Bray Electric Tramway, 462, 502.
Butler, H. W. Secondary Batteries, 417, 461.
Calories and Volts, 546.
Carbon Filaments, 239.
Carbon, Retort, 165.
Cardew, P., Dynamo Testing, 101.
Chambers, R., Retort Carbon, 165.
Connolly, T., Electric Lighting in Mines, 285.
Cook, D., Babbage's Notation, 147.

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CORRESPONDENCE (*continued*):
Cores, The Heating of, 327, 351.
Crabtree, E. W., Stationary Armature Cores, 307.
Cunynghame, H., Soldering Aluminium, 285.
Current in Telephone Circuit—Was it Undulatory? 190.
Cuttris's Siphon Recorder, 103, 239.
Dynamos:—
Characteristics of, 37, 59, 78, 99, 125.
Compound Winding, Varley's Patent, 547.
Elwell-Parker, 286.
Kapp's Formulæ, 239.
Performances of some, 546.
Stanley's, 373.
Stationary Armature Cores, 307.
Testing, 100, 125.
Winding Armatures, 100, 125.
Earthquake in Southern France, 374.
Electioneering and Scientific Societies, 103.
Electric Bells, A Little Puzzle, 126.
Electric Lighting:—
for U. S. Navy, 548.
by Primary Batteries, 285.
in Mines, 285.
at Prince of Wales's Theatre, 373.
Electricity and Magnetism, Elementary, 125, 165.
Elwell-Parker Dynamo, 286.
Faults in Submarine Cables, Kennelly's Rl for Finding, 567.
Fire Alarm, Taussig's, 462, 482, 501.
Fire Insurance, American Practice, 327, 349.
Fisher, W. C., New Accumulator Cell, 14.
FitzGerald, D. G., Secondary Batteries, 439, 461, 501, 545.
Forbes, G., The President of the Telegraph-Engineers, 78.
Fricker, G. C., Notation, 100.
Galvanometer, The Sine, 125.
Higgins, F., Taussig's Fire Alarm, 462, 501.
Hopkinson, E., Dynamo Testing, 100.
Incandescent Lamp Filaments, 239.
Incandescent Lamp Patents, 307.
Incandescent Lamps for Series Circuits, 547.
Induction, Self, in Dynamos, 373.
Jarman's Tramcar, 14.
Kapp, G., Characteristics of Dynamos and Notation, 59, 99.
Kapp's Formulæ for Dynamos, 239.
Kent's Accumulator Switch, 502, 523, 563.
Lever, E., Sunday at our Post Offices, 38.
Lightning Conductors, A Query, 462.
Magnetic Heating, 327, 351.
Maier, J., Taussig's Fire Alarm, 482.
Mather, T., Elementary Electricity and Magnetism, 125.
Maxwell's Theory of Electricity, 395, 418.
Monckman, J., Peltier Effect, 461.
Motors, Sprague and Mordey, 374
Neville, R. H. C., Kent's Accumulator Switch, 523.
Notation, 37, 59, 78, 99, 125.
Notation, Babbage's, 147.
Pardoe, G. T., Fire Insurance, 327.
Peltier Effect, The, 461.
Penruddocke, C., Primary Batteries and Electric Lighting, 285.
Pescod, G. F., Improvements in Thomson's Recorder, 103.
Phenomenon, Remarkable Atmospheric, 308.
Phillips, S. E., Law of Squares, 14.
Phillips, S. E., Volts and Calories, 546.
Pollak Cells, Information Wanted, 327, 351.
Pollitt, R. B., Characteristics of Dynamos, 78.
Power, Electrical Transmission of 500 H.-P., 308, 327.
Prince of Wales's Theatre Installation, 373.
Puzzle, A Little, 126.
Ravenshaw, H., Performances of Some Dynamos, 546.
Recorder, Siphon, Cuttriss and Pescod's Improvements, 103, 239.
Secondary Generators, 60, 565.
Sellon, J. S., Secondary Batteries, 38, 213, 239.
Shippey, A., Secondary Batteries, 482.
Siphon Recorder, Cuttriss's and Pescod's, 103, 239.
Smart, E., Compound Winding, 547.
Society of Telegraph-Engineers, The Presidency, 78, 103.
Soldering Aluminium, 285.
Soldering Joints, 327, 349.

CORRESPONDENCE (*continued*):
Soward, A. W., Carbon Filaments, 239.
Squares, The Law of, 14.
Stanley, W., jun., Self-induction, 373.
Submarine Cables, Faults in, 567.
Sunday at our Post Offices, 38.
Swinburne, J., Testing Dynamos, 125.
Swinburne, J., Theory of Secondary Batteries, 481, 521, 562.
Switches, Automatic, for Accumulators, 502, 523, 563.
Taussig's Fire Alarm, 462, 482, 501.
Telephone Circuit, Current in—Was it Undulatory? 190.
Telephone, First Use of the Name, 521.
Telephone Wires, Overhead, Double, 548.
Thame, H., and Co., Welding by Electricity, 101.
Thomson, E., Alternating Currents, Novel Phenomena, 546.
Tramcar, Electrical, Jarman's, 14.
Trotter, A. P., Winding Armatures, 100.
Undulatory, Query as to Current in Dann's Receiver, 190.
Varnishing Incandescent Lamps, 563.
Volts and Calories, 546.
Ward, R., Incandescent Lamp Patents, 307.
Welding by Electricity, 101.
Wilkinson, H. D., Maxwell's Theory of Electricity, 418.
Williams, E. A., Anode and Cathode, 462.
Williams, E. A., Secondary Batteries, 501, 545.
Wires, Aerial, 374.
Wires, Effect of Strain on Resistance of, 461.
Wires, Overhead, Double, 548.

Correspondents, Answers to, 58, 260, 394, 416, 460.
Cornu and Potier on the Form of the Wave Surface of Light, &c. (*see* CONTEMPORARY PROGRESS).
Cowles' Electric Furnace, 459.
Crompton Dynamo, 199, 200, 214, 304.
Crystals, Magnetic Rotary Power of, by M. Chauvin, 310.

D

DEATHS:—
Bolton, Sir F., 190, 332.
Champain, Colonel Sir J. B., 233, 332.
Frost, A. J., 417.
Guthrie, Prof., 43.
Deprez, M., on Fontaine's Power Transmission Experiments, 39.
Deprez, M., The Magnetic Circuit, 15, 110.
Diehl's System of Operating Incandescent Lamps on Arc Circuits, 351.
Dilute Solutions, Conductivity of, by F. Kohlrausch, 16.
Direct Spanish Telegraph Co. *v.* Ballantyne, 22, 65, 133.
Distribution by Transformers, 77, 551.
Dundalk, The Lighting of, 543.

DYNAMOS:—
Brush and Victoria, 198-9.
Chamberlain-Hookham, 305.
Characteristic of Shunt-wound, by S. P. Thompson, 111.
Characteristics of, by J. and E. Hopkinson, 39, 63, 86, 175.
Characteristics of, by G. Kapp, 20, 43, 63, 110.
Crompton's, 199, 200, 214, 304.
Designing, 110,
Edison-Hopkinson Bar Armature, 347.
Eickmeyer's Ironclad, 437, 465, 484.
Elwell-Parker, 257, 304.
Franklin Institute, Tests of, by C. Hering, 169, 233.
Frölich's Theory of Compound, by K. Zickler, 369, 424.
Ganz and Co's., 216, 237.
Goolden and Trotter's, 238.
Holmes and Co's. "Castle," 238.
Kapp's, 197, 257.
Leakage, Forbes's Lemmas and Leduc's Magnet, 123.
Magnetic Field of, by M. Deprez, 15, 110.
Mather and Platt's "Manchester," 347.
Notes on the Performance of, 499.
Practice of Design, by G. C. Fricker, 412, 434, 477, 518.

DYNAMOS (*continued*):
Paterson and Cooper's Phœnix, 215.
Review of Work done in 1886, 124, 214, 304, 347.
Stafford and Eave's, 238, 505.
Slatter's, 347.
Swan's, 370.
Testing, by J. Swinburne, 8, 31, 75.
Testing Demonstrations at City and Guilds Institute, 177.
Theory of the Alternate Current, by J. Hopkinson, 413.

E

Earth Currents and Solar Phenomena, *see* WILD.
Eastern Extension Co. and New Zealand Cables, 39, 57.
Eck, Callow and Co. *v.* Heath, 114.
Edison-Hopkinson, Bar-armature Dynamo, 347.
Edison-Swan Co. *v.* Woodhouse and Rawson, 133, 154, 267, 284, 291, 336.
Edison's System of Distribution, 263.
Edison's Wire Gauge, 330.
Education, Technical (Leading Article), 438.
Eickmeyer's Dynamo, 437, 465, 484.
Electric Bells, Moseley's Improvements, 85, 152.

ELECTRIC LIGHTING:—
Act Amendment Bill, 313, 382, 402, 447, 460.
Apparatus, Portable, 371.
at Dundalk, 543.
in Graz, 57.
at Hadfield Mills, 376.
Improvement's in Bernstein's System, 202.
Industry in America, 314, 416.
Plant for India, 259.
and Insurance (Leading Article), 13.
for Microscopic Projections, 11.
of Newcastle Exhibition, 172, 510.
in Paris Theatres, Regulations for, 446, 460.
by Primary Batteries, by V. S. Allpress, 33.
Review of Work done in 1886, 195, 237.
Stations, Hourly Variations in Current from, 123, 138.
Stations, Plans for Installing, by A. F Upton, 427.
at Taunton, 126.
for Waterford, 391.

Electric Locomotion, by A. Reckenzaun, 526.
Electric Motors, (*see* MOTORS, ELECTRIC).
Electrical Engineering in Japan, by J. Fujioka, 424.
Electrical Fire Risks (Leading Article), 306.
Electrician, The, and its Readers (Leading Article), 12.
Electricity at Hatfield, 511.
Electricity and Heat, Their Relation, 110.
Electricity and Magnetism, Elementary, 6, 30, 51, 74, 97, 120, 142, 164, 186, 210, 232, 254, 280.
Electricity, Maxwell's Theory of, 311, 353.
Electrolysis, Its Action on an Electrolyte, by S. Arrhenius, 105.
Electrolysis, Faraday's Law of, by W. N. Shaw, 355.
Electrolysis, Mechanical and Thermal Effects of, by E. Bouty, 105.
Electrolysis, For Papers on the Theory of, presented to British Association (*see* Kohlrausch, Bouty, Hopkinson, Fitzgerald, Bidwell, Arrhenius, Shaw, Fitzpatrick, Lodge).
Electrolytic Conductivity, by S. Bidwell, 35.
Electrolytic Conductivity, by Prof. Bouty, 34, 61.
Electromagnetic Induction, by O. Heaviside, 10, 143, 211, 281, 390, 457.
Electromagnets, Action of Solenoids on Iron Cores, by T. Bruger, 147.
Electromagnets—Tension of Lines of Force, by R. H. M. Bosanquet, 83.
Elieson's Electric Tramcar, 256.
Elwell-Parker Dynamo, 257.
Empire, The, and its Cables (Leading Article), 544.
Energy, Transmission of (*see* POWER).
Engine Indicator, Steam, 324.
Engines at the Colonial Exhibition, Tests of, 52.
Engines for Electric Lighting, Society of Arts Medals, 130.
E. P. S. Switches and Ammeters, 467.

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Examination Papers of Science and Art Department, 85.
Exhibition, The Colonial, Tests of Engines at, 52.
Exhibition, Newcastle, Lighting of, 172, 510.

F

Faraday's Law of Electrolysis, by W. N. Shaw, 355.
Fibres, by C. V. Boys, 489.
Field's Electric Tramway, 419.
Finsbury College and the Central Institution, (Leading Article), 480.
Fire and Burglar Alarm, Taussig's 441.
Fire Risks, Electrical, (Leading Article), 306.
FitzGerald, D. G., Calorific Values and E.M.F.'s, 498.
FitzGerald, D. G., Reversible Lead Batteries, 397, 414 442. 457.
FitzGerald, D. G., Professor Thomson's Calorific Equivalents, 457.
Fitzgerald, G. F., and Trouton, Accuracy of Ohm's Law. 34.
Fitzpatrick. T. C., Alternate Currents for Determining the Conductivity of Electrolytes, 400.
Fleming, J. A., Copper Disc Galvanometer for Alternate Currents, 561.
Fontaine, Electrical Transmission of Power, 39.
Football, E.E.F.C. *v.* Resistance F.C., 489.
Forbes, Professor G., The Magnetic Circuit, 123.
Forbes, G., Magnetic Problems, 129.
Foster, G. C., Measuring the Mutual Induction Coefficient of Two Coils, 89, 104 (*errata*), 381.
France and Ocean Cables, 328, 334.
Franklin Institute Tests of Dynamos, by C. Hering, 169, 233.
French, E. L., Relation between Magnetising Force and Core of Magnet, 127.
Fricker, G. C., Practice of Dynamo Design, 412, 434, 477. 518.
Frölich's Theory of Compound Dynamos, by K. Zickler, 369, 424.
Frost, A. J., Death of, 417.
Fujioka, J., Electrical Engineering in Japan, 424.

G

Galvanometer, A Copper Disc, for Alternate Currents, 561.
Ganz and Co.'s Dynamos, 216, 237.
Gas and its Partisans (Leading Article), 329.
Gaslighters, Electric, 509.
Gibson and Gregory, Spun Glass, 381.
Gilman *v.* Gülcher Electric Light Company, 90.
Glass, Tenacity of Spun, by Gibson and Gregory, 381.
Glow Lamps (*see* INCANDESCENT LAMPS).
Goolden and Trotter's Dynamo, 238.
Graphic Methods, Note on, 308.
Guthrie, Professor, Death of, 43.

H

Hadfield Mills, Installation, 376.
Hatfield, Electricity at, 511.
Hearing, New Theory of, 204.
Heat and Electricity, Their Relation, by Clausius, 110.
Heaviside, O., Electromagnetic Induction, 10, 143, 211, 281, 390, 457.
Heaviside, O., Theory of the Telephone and Hysteresis, 302.
Hering, C., Franklin Institute Tests of Dynamos, 169, 233.
High Tension Electricity, Treatment of Sufferers from Effects of, 562.
Hire and Purchase System, The (Leading Article), 146.
Holmes and Co's Castle Dynamo, 238.
Hopkinson, Dr., Electric Conduction, 17.
Hopkinson, J., Induction Coils or "Transformers," 420.
Hopkinson. J., Lighthouses of Macquarie and Tino, 113.
Hopkinson, J., Theory of the Alternate Current Dynamo, 413.
Hopkinson, J. and E., Characteristics of Dynamos, 39, 63, 86, 175.
House, R. E., his Telephone, 88.
Hysteresis, by O. Heaviside, 302.

I

Ice, Electrification of, by Water Friction, 152.
Immisch's Electric Motor, 392.
Incandescent Lamps :—
on Arc Circuits, 351, 414.
Mac-Carthy's Holder, 499.
Manufacture of, by J. Swinburne, 60, 98, 121, 187, 255, 286, 303, 323, 346, 368, 418, 462, 496, 539.
Manufacture of, by General C. E. Webber, 112, 130, 152.
Patents Question, 24.
Table of Breakages at Temesvar, 262.
Varnishing of, by N. K. Cherrill, 484.
Indicator, The Steam Engine, 324.
Induction Coils Graphically Treated, by G. Kapp, 502, 524, 568.
Induction Coils, Measuring the Mutual Induction Coefficient of, Foster and Swinburne, 89, 104 (*errata* 381).
Induction Coils or "Transformers," by J. Hopkinson, 420.
Induction, Electromagnetic, by O. Heaviside, 10, 143, 211, 281, 390, 457.
Induction between Magnet Poles, Leduc's Experiments, 123.
Induction, Mutual, Determination of Coefficients of, by R. H. M. Bosanquet, 381.
Induction, Self, by S. Bidwell, 441.
Induction, Self, of Compound Conductors, by Lord Rayleigh, 170, 222, 240.
Insurance and Electric Lighting (Leading Article), 13.
Ions, Migration of, by O. J. Lodge, 508, 525.

J

Japan, Electrical Engineering in, by J. Fujioka, 424.
Jubilee of the Telegraph (Leading Article), 58.

K

Kapp, G., Characteristics of Dynamos, 20, 43, 63, 110.
Kapp, G., Induction Coils Graphically Treated, 502, 524, 568.
Kapp Dynamo, 197, 198, 257.
Kennelly, A. E., Faults in Cables, 468, 486, 506, 530.
Kent's Switch for Secondary Batteries, 479
Kohlrausch, F., Conductivity of Dilute Solutions, 16.

L

Lancashire and Cheshire Telephone Company's Progress in 1886, 193.
Laryngoscope, Vesey's, 244.
Lay's Torpedo, 394.
Lead Batteries, Reversible, by D. G. FitzGerald, 397, 414, 442, 457.
Lead, Polarisation of, by Streintz and Aulinger, 309.

LEADING ARTICLES :—
Atlantic Cables, Proposed, 59.
Brighton Electric Railway, 260.
Central Institution and Finsbury College, 480.
Edison and Swan *v.* Woodhouse and Rawson, 284.
Electric Light Legislation, 460.
Electric Lighting Business in America, 416.
Electrical Fire Risks, 306.
Empire, The, and its Cables, 544.
France and Ocean Cables, 328.
Gas and its Partisans, 329.
Hire and Purchase System, The, 146.
Insurance and Electric Lighting, 13.
Jubilee of the Telegraph, 58.
Lessons of the Storm (Telegraphic Breakdown), 168.
Long Distance Telephony, The United Telephone Company and, 564.
Metropolitan Board of Works and Overhead Wires, 36.
Ourselves, 12.
Paddington Installation, The, 500.
Reduction of Capital and Dividend, 80.
Review of the Year 1886, 192, 214, 236, 257, 304, 347.

LEADING ARTICLES (*continued*) :
Sense and Science, 124.
Society of Telegraph-Engineers, The Presidency, 31, 102, 124.
Society of Telegraph-Engineers, and Students, 522.
Technical Education Again, 438.
Telephonic Investigations, 372.
Telephony, 102.
The United Telephone Company and Long Distance Telephony, 564.
Underground Telegraphs, 394.

Leduc's Magnet, 123.

LEGAL :—
Anglo-American Brush Corporation *v.* Crompton, 90.
Callow *v.* Young, 68.
Cocks *v.* G. W. Railway, 44, 67, 449, 500.
Direct Spanish Telegraph Co. *v.* Bannatyne, 22, 65, 133.
Eck, Callow and Co. *v.* Heath, 114.
Edison-Swan Co. *v.* Woodhouse and Rawson, 133, 154, 267, 284, 291, 336.
Electric Sun Lamp Co. *v.* Lindsay, 44.
Gilman *v.* Gülcher Electric Light Co., 90.
Macdonald *v.* Slatter and Co., 270.
Re Pilsen-Joel Co., 136.
Simmonds *v.* Volk (Brighton Railway), 269.

Light, Cauchy's Theory of, by J. Walker, 132.
Light, Form of Wave Surface of, &c. (*see* CONTEMPORARY PROGRESS).
Lighthouses of Macquarie and Tino, by J. Hopkinson, 113.
Liquid Surfaces of Revolution, Mean Curvature of, by A. W. Rücker, 89.
Liquids and Gases, by Ramsay and Young, 382.
Liquids, Nature of, by Ramsay and Young, 132.
Lodge, O. J., Abstract of Bouty's Paper on Salt Solutions, 62, 81.
Lodge, O. J., Migration of Ions, 508, 525.

M

Mac-Carthy's Lampholder, 499.
Macdonald *v.* Slatter and Co., 270.
Macquarie and Tino Lighthouses, by J. Hopkinson, 113.
Magnet Core, The Relation between it and Magnetising Force, by E. L. French, 127.
Magnetic Circuit, by M. Deprez, 15, 110.
Magnetic Circuit, Prof. Forbes's Lemmas, 123
Magnetic Field, Measurement of the Intensity of, 571.
Magnetic Induction, by H. Tomlinson, 487.
Magnetic Problems, by G. Forbes, 129.
Magnetic Resistance, by Profs. Ayrton and Perry, 442.
Magnetisation, Sequences of Reversals, by R. H. M. Bosanquet, 551.
Magnets, Permanent—Magnetic Decay, by R. H. M. Bosanquet, 145.
Manchester Electric Supply Co., 114.
Manganese Steel, Barrett's Experiments on, 138.
Magnetite, by Prof. S. P. Thompson, 18.
Martin, T. C., Electric Light Industry in America, 314.
Martin, T. C., Electric Street Cars, 150, 223.
Mather and Platt's "Manchester" Dynamo, 347.
Maxwell's Theory of Electricity, 311, 353.
Measuring Instruments for Testing, New, by W. C. Unwin, 267.
Mercury in the Magnetic Field, 259.
Meters, Electrical, by Sir W. Thomson, 541.
Mining and Electricity, by F. J. Rowan, 377, 421, 439, 464, 483, 504.
Moseley, W., Improvements in Electric Bells, 85, 152.
Motor, Immisch's Electric, 392.
Motors, Electric, in the United States, 314, 571.
Motors for Electric Lighting, Society of Arts Medals, 130.
Motors, Sprague and Mordey, 374.
Moy, T., The Telegraph, 225.

N

National Electric Light Association (United States, America), 416, 424, 427.
National Telephone Co.'s Progress in 1886, 193, 415.

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Newcastle Exhibition Lighting Contracts, 172, 510.
New Telephone Co.'s Progress in 1886, 194.
New Zealand Cables, 39, 57.
Northern District Telephone Co.'s Progress in 1886, 194.

Notes :—
Accident, Fatal, in Regent-street, 209.
Accumulators (*see* Batteries, Secondary).
Acheson's Duplex Wire, 182.
Agricultural Engineers' Association, 535.
Air, Passage of a Current Through, 474.
Air Pumps, 474.
Alkaline Solutions, Electrolysis of, 515.
Alternating Currents in America, 2.
Aluminium, The Smelting of, 182, 429.
Aluminium and Steel for Vessels, 452.
American Bell Telephone Company, 493.
American Electric Light Company, 159
American Electrical Patents, 205.
Ammonic Sulphate, Electrolysis of, 72.
Anglo-American Brush Company, 319.
Appointments :—
Walmsley, R M., Principal, Technical College, Kurrachee, 47.
Rücker, Prof., Physics Chair, Normal School of Science, 69.
Drake, B., Electrical Engineer, Bank of England, 115.
Elliott, A. C., Demonstrator, Edinburgh University, 319.
Hunter, A., Postmaster at Leven, 557.
Nisbet, W., Assistant Telegraph Superintendent, Glasgow, 535.
Arago's Centenary, 117.
Arago's Incandescent Lamp, 182.
Arc or Incandescent in 1834, 182.
Arc, Method of Starting without Contact, 517.
Arc-Lamp Post, 160.
Arc-Light Carbons, Manufacture of, 453.
Arc Lighting, Cost of, 117.
Arc Works, Chelmsford, Dinner, 301.
Artesian Wells for Supplying Motive Power, 2.
Artificial Lighting, 94.
Atlantic Cables, Proposed, 49.
Atmospheric Electricity, 182.
Aurora, Display of, 344, 429.
Australia, Conference on Telegraph Rates, 47, 115.
Austrian Telegraphs and the Snowstorm, 431.
Baines, F. E., Marriage of, 514.
Balloon Society's Jubilee Medal and Prize, 408.
Batteries, Primary :—
Bailey's, 513.
Daniell, for the Pocket, 386.
for Electric Lighting, 278.
Lugo's Three-Liquid, 297.
Guoy's Standard Cell, 454.
Schanschieff's, 429.
Tungstic Acid for, 297.
Upward's, 429.
Water, 365.
Batteries, Secondary :—
the E.P.S., 159.
for the Pocket, how to Make, 537.
Julien's for Tramcars, 140, 513.
for Lifeboats, 162.
Management of, 72, 431.
Mercury Contacts for, 452.
Schanschieff's, for Miners' Lamp, 537.
Van Gestel's Cell, 536.
the Union Cell, 139.
in the United States, 342, 491.
Battery Solution, a New, 559.
Baxter Technical Institute, 159.
Bell, Prof. A. G., Fire at his House, 249.
Bell, Prof. A. G., on the Telephone, 474.
Bell Telephone Patents in America, 47, 160, 276, 298, 363, 451.
Bell Telephone Patents in Austria, 403, 475.
Belting, New Types of, 276.
Berlin Edison Company, The, 228.
Betting Fraud, Attempted, 47.
Birmingham Provisional Order, 2.
Bitumen Conduits, 319.
Blackman Air Propeller, 491.
Blasting with Frictional Electricity, Dangers of, 73
Blavier, E., Death of, 227.
Bleaching by Electrolysis, 411.
Blewett, G., Death of, 474.
Boilers, Low-water Alarm for, 116, 182.

Notes (*continued*):
Bolton, College for, 407.
Bolton, Sir F., Funeral of, 207.
Books, New, 47, 69, 115, 137, 205, 207, 227, 250, 275, 297, 341, 363, 385, 407, 429, 473, 491, 535, 536.
Boudet's Method of Reproducing Designs, 95.
Bray Electric Tramway, 275, 430, 451.
Brighton Electric Light Company, 2, 94, 386.
Brighton Electric Railway, 26, 275.
British Association at Birmingham, 116.
British Association, Programme of Manchester Meeting, 409.
Brockie-Pell Lamp at Blackpool, 320.
Brooks *v.* Bell Telephone Company, 341.
Brown, J., Theory of Voltaic Action, 161.
Brush "Colossus" Dynamo, 50.
Building Trades' Exhibition, Awards, 473.
Burmese Telegraphs, 181, 452.
Cable, Atlantic, Case of Fouling, 47.
Cable Competition, Mr. Raikes on, 137.
Cable Conference, International, 93.
Cable Repairing, Quick Work, 276.
Cable-Ships, Launch of, 27, 115, 453.
Cables, Atlantic, Proposed, 49.
Cables, Interrupted, 69, 115, 275, 364, 429, 451, 491.
Cables, New, 25, 28, 47, 49, 69.
Cables, Repaired, 25, 47, 70, 93, 115, 159, 276, 451, 473, 491, 535.
Caledonian Railway, Duplex Needle Working on, 431.
Californian Vineyards, Electricity in, 160.
Callender and Webber's Underground Cable Conduit, 28
Canadian Telegraphs, 277, 299.
Carbon Cutting Machine, Howell's, 476.
Carbon, Effect of Stress on Resistance of, 29.
Carbon from Seaweed, 181.
Carbons, Price of in America, 181.
Ceylon, Power Transmission in, 161.
Champain, Col. Sir J. B., Death of, 321.
Chimneys, Tall, and Lightning Conductors, 365.
China, The Telegraphs in, 407.
Chinese Telegraphs, 116, 275.
Churchwarden's Hat, The, 321.
Circuits, Open, Closed and Magnetic, 184.
Clocks, Electric, in Mexico, 492.
Clocks, Electric, in Venezuela, 115.
Coastguards' Stations and the Telegraph, 473.
Colliery Disaster, 69.
Colonial Conference, 115, 205, 473, 535.
Commercial Cable Co., 205.
Companies, New, 251.
Compass Errors, 1.
Condenser, The, on Telephone Circuits, 96.
Conductivity of Solid Substances at High Pressure, 183.
Conductivity, Variation of Through Pressure, Early Reference to, 535.
Conversazione at City and Guilds Institute, 410.
Copper Ores, Electrolyic Treatment of, 344.
Cowles' Process of Smelting Aluminium, 182, 429.
Creil Experiments, The, 26, 137.
Crompton and Co's. Works, Visit to, 93.
Current, Passage of Through Air, 474.
Currents, Dangerous, 538.
Davis, Daniel, Death of, 494.
Deaths :—
Bolton, Sir F., 207.
Blavier, E., 227.
Blewett, G., 474.
Davis, Daniel, 494.
Gaiffe, A., 513.
Deprez's Experiments at Creil, 26, 137.
Designs, Reproducing, 95.
Diehl's Induction System, 363.
Dielectrics by J. Currie, 162.
Direct Spanish Telegraph Co., 182.
Distribution of Electricity, Westinghouse's Patent, 26.
Dundee, New Technical Institute, 159.
Dunn, —, Decorated by Chinese Government, 275.
Dust, Deposition of by Electricity, 138.
Dynamos :—
Boltmann's, 342.
Brush "Colossus," 50.
Determining Characteristics of, 409.
Edison's Big, 138.
English *v.* American, 118.

Notes (*continued*):
Dynamos :—
A Big Ferranti, 26.
Large, for Power Transmission, 452.
Long Runs, 2.
Method of Insulating, 386.
a Multipolar Continuous Current, 559.
New Term for Air-Space, 115, 491.
Portable Hand Machine, 516.
Stanley's, 230.
Slatter-Joel, The, 363.
and Telephones, 139, 297.
Earth's Magnetism, Value of H. in Buildings, 298.
Earthquakes, 344, 409, 513.
Eastern Telegraph Co. in Spain, 277.
Edinburgh Exhibition Awards, 25, 47, 69.
Edison, T. A., Illness of, 205, 249, 319.
Edison Dynamo, Big, 138.
Edison Electric Light Company, 219.
Edison Lamps in the United States, 343.
Edison Municipal System, 342.
Edison System in France, 205, 249.
Effluviography, 71.
Electric Alarms for Mortuary Chapels, 559.
Electric Discharge, Effect of, on Gelatine Bromide Plate, 71.
Electric Hoist, 275.
Electric Lighting Act Amendment Bill, 275, 473.
Electric Lighting Act, Prof. Robinson on, 314.
Electric Lighting :—
for Advertising Purposes, 341.
and Agriculture in Russia, 3.
in Banks, 47.
for Bartholdi's Statue, 3, 26, 47.
by Batteries, 278.
at Bordeaux, 557.
on Bournemouth Pier, 491, 513.
in Brighton Pavilion, 141, 341, 452.
in British Museum, 25, 94.
at Bruyéres (Vosges), 557.
for Canals, 69.
in Churches, 4, 48, 69, 93, 181.
at the Colinderies, 229.
on the Congo, 491.
Cost of, 117, 138.
in the *Daily Graphic* Offices, 491.
on the Dardanelles, 25.
in Dockyards, 181.
of an Edinburgh College, 407.
at Elberfeld, 558.
at the Elysée Ball, 385.
Fatal Accident in Regent-street, 209.
and Fire Insurance in America, 28, 300.
at Folkestone, 557.
at French Railway Exhibition, 385.
in *Freeman's Journal* Offices, 455, 491.
and Gas, 228, 229, 343, 365, 366.
at Grand Hotel, Brussels, 385.
in Great Eastern Hotel, Calcutta, 277.
at Grimsby Docks, 557.
for Harbour Defence, 363, 385.
at Hereford, 557.
at Hotel de Ville, Vienna, 48.
at the House of Commons, 385.
in India, Jubilee Illuminations, 495.
Inspectorship in America, 320.
at Leeds Music Hall, 1.
in Libraries, 453.
at Liége Museum, 429.
in Lighthouses, 119, 140, 454.
of Madras Station of E.E.T.C., 407.
at the Manchester Exhibition, 253, 536, 558.
at Marlborough House, 407.
at Milan, 558.
in Mills and Works, 3, 93, 115, 137, 159, 181, 182, 253, 275, 364, 476, 513, 537.
in Mines, 26, 48, 69, 208, 385, 433, 452.
National United States Association, 320 365, 388.
at Newcastle Exhibition, 319, 341, 473.
in Oldham Town Hall, 115.
in Palais Indien, Antwerp, 513.
at Panama Canal Works, 341.
of Paris (1889) Exhibition, 454.
at Paris Hotel de Ville, 363, 514.
for Pearl Fishing, 137.
for Photography, 385.
in Private Houses, 27, 137, 249, 319, 385, 451, 473.
at Rheims, 557.
in Royal Palace, Stockholm, 341.

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NOTES (continued):
Electric Lighting:—
on Ships and Boats, 69, 70, 94, 117, 137, 160, 181, 249, 298, 363, 433, 451, 475.
in Shops and Offices, 27.
at Southport, 556.
and Spiders, 342.
at St Aignan (Loir-et-Cher), 557.
at St. James's Hall, 557.
and the Suez Canal, 94, 297, 364.
Temporary Installations, 115, 137, 159, 205, 385, 493.
in Theatres, 138, 141, 181, 250, 276, 319, 386, 491, 535.
the Tower System, 319.
in Towns Abroad, 1, 25, 27, 48, 69, 70, 72, 137, 138, 159, 160, 161, 182, 205, 227, 229, 249, 275, 297, 322, 341, 363, 364, 407, 429, 430, 432, 451, 453, 493, 495, 513, 535.
in Towns at Home, 4, 48, 49, 69, 93, 137, 205, 206, 228, 249, 250, 278, 298, 319, 320, 341, 386, 387, 388, 451, 492, 514, 517, 536.
on Trains, 26, 70, 72, 93, 94, 95, 119, 139, 408, 473, 474, 493, 516.
and Vegetation, 47.
in Vienna General Post Office, 69.
at Waterford, 558.
at Westminster Aquarium, 560.
at Windsor Castle, 385.
at Winter Palace, St. Petersburg, 536.
Electric Transmission of Power in Paris, 557.
Electric Whistle, 473.
Electrical Phenomenon, 160, 162.
Electricity in Californian Vineyards, 160.
Electricity, Capital Punishment by, 407.
Electricity in the Cemetery, 3.
Electricity, The Distribution of, Westinghouse's Patent, 26.
Electricity, Prof. Houston on the Future of, 388.
Electricity for Therapeutical Purposes, 118.
Electro-Calorimeter, 301.
Electrolysis of Ammonic Sulphate, 72.
Electrolytic Polarisation, by C. Fromme, 476.
Electrolytes, Thermoelectric Properties of, 206.
Electro-Technics, Study of, 431.
E.M.F. and Difference of Potential, 141.
E.M.F., Seat of, by J. Brown, 161.
Electromotive Forces, Dangerous, 538.
Electro-plating Flowers and Insects, 559.
Engine, Manual, for Driving Dynamos, 26.
E.P.S. Co.'s Work, 27.
Equipotential Curves, 411.
Examples of Exercises, 250.
Execution by Electricity, 407.
Exhibitions:—
Barcelona, 407; Brussels, 93, 227, 275, 491; Edinboro', 25, 47, 69; Liverpool, 47; Manchester, 26, 253, 536; Newcastle, 319, 341, 429, 473; Paris (1886), 93; Paris (1889), 25, 341, 454; Telegraph Jubilee, 93; Vienna, 161.
Falls of Clyde, Utilisation of, 363.
Farmer, M. G., Self-Induction, Curious Facts, 389.
Farming and Electricity, 473.
Fawcett Memorial, The, 250, 275.
Field Telegraph for Portugal, 474.
Field's Motor Regulator, 299.
Figures, Some, 251
Finsbury Technical College Magazine, 535.
Fire Alarms, Value of, 319.
Fire at Battersea, 319.
Fire in Dr. Muirhead's Laboratory, 451.
Fire Insurance in America, 28, 300.
Fluorescence from Electric Discharge, 3.
France and England, Telegraphic Communication Between, 298.
France, A State Electrical Laboratory for, 246.
Franco-German Urbanities, 138.
Franklin, B., A Panegyric, 342.
French Academy Prizes, 183.
French Electrical Society, New, 251.
French Telegraphs, 319
Gaiffe, A., Death of, 513.
Gale, Severe, 93, 115.
Galvanometer, D'Arsonval's, 475.
Gas in America, Price of, 1.
Gas and Electric Lighting, 228, 229, 249, 343, 365, 366.
Gas Explosion in Electric Light Station, 249.
Gas Explosion in a Telegraph Pipe, 557.

NOTES (continued):
Gases, Conduction of Electricity by, 366.
Gases, Hall's Phenomenon in, 206.
Gaulard-Gibbs System, The, 70, 492.
German Patent Law, 430.
German Patent Office, 473
German Post and Telegraph *Employés*, 491.
Gimé Incandescent Lamp, 494.
Governors for Engines, Electrical, 48.
H., its Value in Buildings, 298.
Hall's Phenomenon in Gases, 206.
Hampton Court Palace, Fire Alarms at, 48.
Havannah-Key West Cables Renewal of, 26.
Hay Fever and Asthma Cured by Electric Cautery, 25.
Heat, its Direct Conversion into Electrical Energy, 321.
Houses of Parliament Sewerage, 250.
Houston, Prof., on the Future of Electricity, 388.
Hydro-Electric Baths, 473.
Hysteresis, 491.
Incandescent or Arc in 1834, 182.
Incandescent Circuits, Indicating Potential of, 183.
Incandescent Lamps:—
The Gimé, 494.
Improvements in, 408.
Litigation, 299.
Lyman and Wheeler's, 139.
Puluj's, 250.
Rumours from America, 249.
Safety Circuit for, 276.
Swedish, 249.
Thomson-Houston, 297.
Varnishing, 513.
Zanni's Filament for, 206.
Indian and Colonial Exhibition Sale, 276, 297, 320
Indian Military Telegraphs, 491.
Indian Telegraphs, 250, 279, 363.
Indicator Lectures, by Prof. Perry, 182.
Induction, Self, Some Curious Facts, 389.
Influence Machines, Method of Distinguishing between Poles of, 515.
International Congress of Science, 277.
International Society of Electricians, 94, 491.
International Telegraphy, 557.
Iron, Effect of Current on When Cooling, 407.
Iron, Magnetisation of in Strong Fields, 495.
Iron, Method of Rendering it Inoxydisable, 183.
Iron and Steel Recalescence, Experiments on, 208.
Isle of May Lighthouse, 119, 140.
Japan Telegraphs, 451.
Jenkin, F., Biography of, 491.
Journal, New, 363.
Jubilee of the Telegraph, 25, 93.
Julien's Battery for Tramcars, 140, 159, 513.
Junior Engineering Society, 48.
"Kapunda," Loss of, 451.
Key, Maiché's Double Current, 206.
King's College *Conversazione*, 95.
Launches, Electric, 410.
Law Courts, Whispers in, 138.
Lead, Electrolytic Desilverisation of, 185.
Leclanché Cells, Regenerating, 299.
Legal:—
Bell Patents in America, 47, 160, 276, 298, 363, 451.
Brooks *v.* Bell Telephone Company, 341.
Bell Patents in Austria, 408, 475.
Edison Telephone Patents in Belgium, 429.
Secondary Battery Patents in America, 491.
Westinghouse *v.* Sun Electric Company, 492.
Siemens Motor Patents, 513.
Letter-boxes, Electric, 297.
Lifeboats and Electricity, 162.
Light, Distribution of, 454.
Lightning, Accidents from, 69, 93, 115, 451, 535.
at a Cable Office, 516.
Conductors, The Erection of, 138.
Conductors and Tall Chimneys, 365.
Flash, Energy of, 251.
Flashes, Leyst's Observations of, 70.
and Photographs, 72.
Protectors for Telegraph Circuits, 207.
Society for Protecting Life, &c., from, 96.
Some Curious Facts on Self-Induction, 389.

NOTES (continued):
Lighthouses, Electric Lighting in, 119, 140, 319, 454.
Lightships, Communication with, 343, 385, 408, 429.
Liquid Surface Tension, Experiment on, 515.
Liquids, Paramagnetic, Method of Showing Movements of, 409.
Littlehampton Electric Tramway, 25.
Liverpool Electric Supply Company, 26.
Liverpool Exhibition Awards, 47.
Lyman and Wheeler's Incandescent Lamp, 139.
Magnetic Coils in Parallel, 300.
Magnets, Specific Induction of, 183.
Magnets and Water, New Experiment, 25.
Magnetic Circuits by Prof. Mascart, 184.
Magnetic Equipotential Curves, 411.
Magnetic Heating, 278, 364.
Magnetic Insulation, 206.
Magnetism, A Query in, 514.
Magneto Machine, Maiché's, 430.
Maiché's Double Current Key, 206.
May Island Lighthouse, 319.
Medical Experiments, Extraordinary, 71.
Mercury Contacts, 407.
Metallurgy, Electric, 297.
Meteorology, Electric, 252.
Meters, Spiral Springs for, 185, 432.
Microphone and Water Leaks, 250.
Milan, Proposed School of Electricity, 137.
Miner's Lamps, Schanschieff's, 537.
"Monarch" Cableship, Quick Work by, 70.
Moonwatcher Wanted, 454.
Morocco Telegraphs, 297.
Motors, Electric:—
Field's Regulator for, 299.
Future of, 388.
in New York, 3.
for Passenger Lifts, 116.
for Sewing Machines, 138.
Siemens *v.* Julien, 513.
Small, 364.
F. J. Sprague and his Critics, 345, 367.
for Working Heavy Guns, 342.
National Telephone Company, 1, 48, 251, 276, 297, 513
National United States Electric Light Association, 320, 365, 388.
"Nautilus," The, 140.
Needle Instruments Worked Duplex, 431.
New Orleans and Overhead Wires, 494.
New Thames Tunnel Railway, 387.
New York Electric Club, 25.
New York Herald, The, 115.
New York Lighting Report, 495.
New York Tram Lines, Julien's Battery for, 140.
Newspapers and Telegraphy, 408.
Niagara Falls, Proposed Utilisation of, 159, 385.
Nickel-Plated Cooking Vessels, 159.
Nitrogen, Passage of Discharge through, 475.
Ozone, Production of, 473.
Pacific Cable Company, 69.
Paramagnetic Liquids, Method of Showing Movements of, 409.
Paris and Scott's Transformers, 139.
Parsoné, E. W., Order Conferred on, 363.
Passenger Lifts, Motors for, 116.
Patent Law, Report of Committee on, 431.
Patents, A Hard Nut, 385.
"Peacemaker," The, 117.
Phenomenon, Electrical, 160, 162.
Philadelphia, Report of Electrical Department, 493.
Phœnix Fire Office Rules, 321.
Phonophore, The, 409.
Photography at Telegraph Stations, 227.
Photometer, Weber's, 430.
Photometry, Branley's Experiments, 455.
Platinum, Price of, 297.
Platitudes, Some, 537.
Porcelain Kilns and the Pyrometer, 299.
Post Office and the Storm, 231.
Post Office and the Telephone, 275, 300, 453.
Postal Telegraph Mechanics, 279.
Postal Telegraph Revenue, 181, 343.
Power, The Distribution of, 4, 26.
Power Transmission in Ceylon, 161.
Power Transmission at Paris, 342.
Power Transmission in Spain, 323, 430.
Practice *v.* Theory, 366.
Printing by Electricity, 47.
Private and Confidential, 251.

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NOTES (continued):
Private Wires in the States, 94.
Prizes Offered by French Academy, 183.
Probing by Electricity, 432.
Provisional Orders, 2.
Pyro-Electricity, 515.
Quadruplex Telegraphy in India, 363.
Quarrie's System of Generating Electricity, 207.
Queensland Telegraphs, 116.
Railway Rates for Electric Machinery, 342.
Railways, Electric :—
in Austria, 205.
at Brighton, 26, 275.
in Russia, 451.
in Switzerland, 298.
Total in the World, 1.
in the United States, 25, 514.
Recalescence, Thermo Electric Study of, 208.
Royal Society of Edinburgh, 514.
Sanitas, 452.
Schanschieff's Battery for Miners' Lamps, 537.
School of Electrical Engineering, 207, 536.
Schoolboy Definitions, 514.
Scott's Torpedo, 473.
Series System, Constant Current in, 560.
Silicium Bronze Wire, 275.
Silvertown Cableship, Return of, from Africa, 28.
Siren, Electric, 536.
Sixpenny Telegrams, 385.
Snowstorm, The, and Austrian Telegraphs, 431.
Snowstorm, The, and Telegraphic Communication with the Continent, 162, 183, 184, 227, 231.
Soap Bubbles and Electricity, 205.
Société Général des Telephones, 205.
Society of Telegraph-Engineers, Premiums Awarded by, 138.
Society of Telegraph-Engineers, Students' Meetings, 516.
Spain, Export of Telegraph Apparatus to, 25.
Spain, Power Transmission in, 322, 430.
Spiral Springs for Meters, 185, 432.
Sprague, F. J., and his Critics, 345, 367.
Static Electricity, Interesting Experiments, 493.
Steno-Telegraphy, Cassagne's System, 159.
Submarine Boat, New, 69, 117, 141.
Submarine Telegraph Company, 298.
Target Indicator, Automatic, 299.
Telegrams by Telephone in Belgium, 205.
TELEGRAPH :—
in America, Early Days of, 453.
in the Argentine Republic, 70.
Boys, Mounted, in Washington, 452.
Clerks' Grievances, 27, 71, 95, 116, 163, 252, 320, 342, 430, 474.
in Holland, 2.
Offices, Provincial, Overtime in, 474.
Schools in America, 94.
in Spain, 70.
Statistics, 409.
System, Singular Development of, 492.
and Telephone, Simultaneous System, 454.
in the West Islands, 557.
Wires of the World, 297.
Telegraphic Addresses, Abbreviated, 513.
Telegraphic Breakdown, 184.
Telegraphic Communication with the Continent and the Snowstorm, 162, 183, 184, 227, 231.
Telegraphic Communication between England and France, 298.
Telegraphic Play, A., 1.
Telegraphy, Competition in, 137.
Telegraphy, Early Progress of, 71.
TELEPHONE :—
in America, 93, 115, 137.
in Austria, 205, 252, 408, 473, 475.
in Belgium, 2, 49, 115, 491.
Prof. A. G. Bell on, 474.
Bell's Patents in Austria, 408.
Breakdown of Wires, 162, 183, 184, 227, 231, 251, 386, 407, 473.
Bridge, 249, 275.
in Bristol, 1, 491.
in China, 492.
in Circuit with Condensers, 95.
at Cockermouth, 557.
Edison Patents in Belgium, 429.
Exhibition at Brussels, 227, 275.
Extension in Kensington, 5.

NOTES (continued):
Telephone :—
First Use of the Word, 492
in France, 159, 205, 297, 343, 492.
in Genoa, 249.
in Germany, 69, 297, 386, 492.
and Government, 2.
Herz's, 386.
Hypnotising by, 452.
in India, 410.
Joke, A Telling, 451.
Litigation re Bell's Patents, 47, 160, 276, 298, 363, 451.
Between London and Croydon, 408.
Long Distance Trials at Sunderland, 364.
Lowther's, 2.
at Margate, 227.
Morton's New, 228.
Mourlon's Book on, 207.
in Northampton, 137.
in Nottingham, 137.
Paris-Brussels Line, 49, 138, 209, 275, 343, 364, 429, 491, 514, 535.
Between Paris and London, 492.
Between Paris and Marseilles, 451.
Poles, Iron v. Wood, 223.
and the Post Office, 275, 300, 453.
in Preston, 73.
at St. Bernard, 249.
in Scotland, 251, 297, 319, 491, 513.
Serious Strike, 319.
as a Source of Infection, 408.
in the South of England, 206, 319, 491.
in Spain, 1, 115.
Statistics of, in Europe, 137.
at Stockholm, 557.
Suicide by, 47.
Syndicates, 5.
in Tangiers, 535.
Telegrams sent by in Belgium, 205.
Theory of the, 557.
Thompson's, S. P., Dynamo Instruments, 139, 297.
Toll Lines in America, 115.
Tuning an Organ by, 558.
in Victoria, 385.
Telephoning without Wires, 3.
Telephony, Duplex, Rosebrugh's System, 28.
Telephony, International, 557.
Telephony, Long-distance, 71.
Terrestrial Magnetism and Sunspots, 250.
Thames Tunnel Railway, New, 387.
Thermo-Electric Properties of Electrolytes, 206.
Thunderstorms, Study of, 160.
Tomlinson, H., Effect of Stress on Carbon, 29.
Tommasi's Experiments on the Silent Discharge, 71.
Tonquin, The Telegraph in, 161, 407.
Torpedoes Fired by Electricity, 252.
Trams, Communication between Passenger and Guard, 181.
Tramways, Electric :—
in Algeria, 363.
in America, 451.
at Blackpool, 535.
at Bray, 25, 275, 430, 451.
in Brussels, 513.
at Littlehampton, 25.
in New York, 93.
in Philadelphia, 25.
in Rio de Janeiro, 159, 513.
Tramway, Proposed Underground in London, 159.
Transformers, Paris and Scott's 139.
Transformer Patents, Early, 559.
Transformers at Rheims, 138.
Tyndall, Dr., Resignation of, 473.
Underground Cable Conduits, Callender and Webber's, 23.
Underground Tramway in London, Proposed, 159.
Union Electrical Company, 251.
Union Storage Battery, 139.
United States Patent Office, 2.
United Telephone Company and its Clients, 251, 407.
United Telephone Company, Views of, 230.
Venezuela, Electrical Phenomenon in, 162.
Vienna Exhibition Report, 161.
Volk Testimonial, 275.
Volta Prize, The, 513.
Voltaic Action, Theory of, by J. Brown, 161.
Water Battery, Simple, 365.
Watt-Hours, 1,000, Comparative Cost of, 514.

NOTES (continued):
Weber's Photometer, 430.
Welding by Electricity, 71, 228.
West African Cables, 28.
Western and Brazilian Telegraph Company, 227.
Westinghouse Company, and the Stanley Dynamo, 230.
Westinghouse v. Sun Electric Company, 492.
Winter's Block System, 557.
Wire, Acheson's Duplex, 182.
Wire, Sentence for Cutting a, 1.
Wires, Overhead :—
Accident from, 451, 473.
in Austria, 205.
and the Chambers of Commerce, 298.
Flad's Plan of Carrying, 205, 451.
in London, 27, 134, 407.
in New Orleans, 494.
v. Underground, 560.
Wires, Underground :—
in Birmingham, 250.
in Boston, U.S., 116.
Callender and Webber's Conduit for, 28.
in France, 299.
in Germany, 227.
between Large Towns in England, 298.
in London, 385.
in New York, 1, 320, 408.
v. Overhead, 560.
Wires, Private, in the States, 94.
Wires, Stranded, v. Solid, 341.
Woodhouse and Rawson's Company's Annual Dinner, 138.
Zanni's Incandescent Filament, 206.
Zetsche, Dr., resigns Editorship of *Electro-Technische Zeitschrift*, 275.

O

Ohm's Law, Accuracy of, by G. F. Fitzgerald and Trouton, 34.
Ore Separator, Wenström's, 213.
Ottesen, R. H., Battery Resistance, 426.
Ourselves (Leading Article), 12.

P

Paddington Installation, The (Leading Article) 500.
Palladium, Successful Deposition of, 149.
Paterson and Cooper's Lighting Plant for India 259.
Paxman's Engines at the Colonial Exhibition Tests of, 52.
Pfannkuche's Commutator, 523.
Phœnix Fire Insurance Co.'s Rules, 306.
Pilsen-Joel Co., Reduction of Capital, 136.
Postal Telegraphs, Work of 1886, 236.
Potassic Chloride, Conductivity of, by E. Bouty, 311.
Power Transmission, Deprez's Experiments, 39.
Power Transmission, Extensive Scheme in Spain, 435.
Preece, W. H., Limiting Distance of Speech by Telephone, 395.
Preece, W. H., Portrait and Biography of, 477.

R

Railway, Electric, The Bentley-Knight System, 240.
Railway, Electric, at Brighton, 260, 269.
Railway, Electric, The Short-Nesmith, 549.
Ramsay and Young, The Influence of Change on Vapour Pressure, 132.
Ramsay and Young, Liquids and Gases, 382.
Ramsay and Young, Nature of Liquids, 132.
Rayleigh, Lord, Self-Induction of Compound Conductors, 170, 222, 240.
Reckenzaun, A., Electric Locomotion, 526.
Review of the Year 1886, 192, 214, 236, 257, 304, 347.

REVIEWS OF BOOKS :—
Ayrton, W. E., Practical Electricity, 349.
Clerke, D., The Gas Engine, 165.
Delahaye, P., L'Annee Electrique, 349.
Fleming, J. A., Lectures to Artisans, 15.
Jamieson, A., Text Book on the Steam Engine, 201.

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REVIEWS OF BOOKS *(continued)*:
Jeans, W. T., Lives of the Electricians, 104.
Martin and Weltzler, The Electric Motor, 326.
Munro, J., Electricity and its Uses, 349.
Nipher, F., Magnetic Measurements, 104, 137.
Tain, H. C., Magnetism and Electricity, 371.
Urbanitsky, Dr. A. R von, Electricity in the Service of Man, 283

Rosebrugh, A. M., Duplex Telephony, 378.
Rowan, F. J., Electricity and Mining, 377, 421, 439, 464, 483, 504.
Rücker, A. W., Mean Curvature of Liquid Surfaces of Revolution, 89.
Rutherford, Dr. W., The Sense of Hearing, 204.

S

Sargent's Telephone, 202.
Schlesinger, M., his Electric Tramway, 18.
Secondary Generators, 551 (*see* TRANSFORMERS).
Sense and Science (Leading Article), 124.
Share List, 24, 46, 68, 92, 114, 136, 158, 180, 204, 226, 248, 274, 296, 318, 340, 362, 384, 406, 428, 450, 472, 490, 512, 534, 555, 574.
Shaw, W. N., Faraday's Law of Electrolysis, 355.
Short-Nesmith Electric Railway, 549.
Siemens and Halske's System of Transformers, 77.

SOCIETIES' MEETINGS:—
ARTS:—
Motors for Electric Lighting, Proposed Tests, 130.
Reckenzaun, Electric Locomotion, 526.
Webber on Glow Lamp Manufacture, 112, 130.

BALLOON:—
Moy, The Telegraph, 225.

BRITISH ASSOCIATION:—
Arrhenius on the Action of Electrolysis on an Electrolyte, 105.
Arrhenius, Conductivity of Aqueous Acid Solutions, 217
Bouty on the Conductivity of Weak Saline Solutions, 62, 81.
Bouty on the Mechanical and Thermal Effects of Electrolysis, 105.
Bouty and Bidwell on Electrolytic Conductivity, 34, 35, 61.
Bouty and Foussereau on Alternate Currents for Measuring Liquid Resistances, 105.
FitzGerald and Trouton on Ohm's Law, 34.
Fitzpatrick, Alternating Currents for Determining the Conductivity of Electrolytes, 400.
Hopkinson on Electric Conduction, 17.
Kohlrausch on Conductivity of Dilute Solutions, 16.
Lodge, Migration of Ions, 508, 525.
Shaw, Faraday's Law of Electrolysis, 355.

CIVIL ENGINEERS:—
Hopkinson, on the Macquarie and Tino Lighthouses, 113.

PHYSICAL:—
Abercromby on Sunrise Shadows in Ceylon, 43.
Ayrton and Perry, Capacity of Dielectric, 442.
Ayrton and Perry, Magnetic Resistance, 442.
Bidwell, Resistance of Suspended Wires, 441.
Bidwell's Peroxide of Lead Cell, 132.
Bidwell, Self-Induction, 441.
Bosanquet, Coefficients of Mutual Induction, 381.
Bosanquet, Magnetisation, Sequences of Reversals, 551.
Boys, Fibres, 489.
Clayden on Thermometers, 43.
Council Report for 1886, 381.
Foster on Measuring the Mutual Induction Coefficient of Two Coils, 89, (*errata* 104), 381.

SOCIETIES' MEETINGS *(continued)*:
Physical:—
Gibson and Gregory, Spun Glass, 381.
Guthrie, Professor, Death of, 43.
Ramsay and Young on Liquids, 132.
Ramsay and Young, Liquids and Gases, 382.
Ramsay and Young on Vapour Pressure, 132.
Rücker on Mean Curvature of Liquid Surfaces of Revolution, 89.
Swinburne, Foster's Method of Measuring the Mutual Induction Coefficient of Two Coils, 381.
Tomlinson, Effect of Increase in Temperature on Iron, 267.
Unwin, Testing Instruments, 267.
Walker on Cauchy's Theory of Light, 132.

TELEGRAPH-ENGINEERS:—
Announcements and Resolutions concerning the Deaths of Sir F. Bolton and Colonel Champain, 332.
Annual Meeting, 129.
FitzGerald, D. G., Reversible Lead Batteries, 397, 414, 442, 457.
Forbes, Magnetic Problems, 129.
Kapp, Dynamo Characteristics, 20, 43, 63, 110.
Kennelly, A. E., Faults in Cables, 468, 486, 506, 530.
The Presidency (Leading Article), 81, 102, 124.
President's Address, by Sir C. Bright, 219, 245.
Students' Meetings, Proposed, 522.
Thompson, S P., Telephonic Investigations, 287, 332, 372, 380.

Solar Phenomena and Magnetic Disturbances, by H. Wild, 310.
Solenoids, Action of, On Iron Cores, by T. Bruger, 147.
South of England Telephone Co.'s Progress in 1886, 194.
South Kensington Examination Papers, 85.
Sprague's Electric Motor, Cost of Supplying Power by, 314.
Stafford and Eave's Dynamo, 238, 506.
Slatter's Dynamo, 347.
Storm, The, Lessons of (Telegraphic Breakdown, Leading Article), 168.
Street Cars, Electric, by T. C. Martin, 150, 223.
Streintz and Aulinger. Polarisation of Lead, 309.
Stress and Strain, Their Influence on Matter, *see* TOMLINSON on Magnetic Induction
Submarine Telegraphy, 456, 482, 497, 520.
Sun Lamp Co. *v.* Lindsay, 44.
Sunrise Shadows in Ceylon, by R Abercromby, 43.
Supplement to *The Electrician* for April 8, Portrait of W. H. Preece.
Swan's Dynamo, 370.
Swinburne, J., Incandescent Lamp Manufacture, 60, 98, 121, 187, 255, 286, 303, 323, 346, 368, 418, 462, 495, 539.
Swinburne, J., Measuring the Mutual Induction of Two Coils, 381.
Swinburne J., Secondary Cells, 153, 173.
Swinburne, J., Testing Dynamos, 8, 31, 75.
Switches and Ammeters, the E.P.S., 467.

T

Taunton, Electric Lighting at, 126.
Taussig's Fire and Burglar Alarm, 441.
Technical Criticism, 519.
Telegraph, The, by T. Moy, 225.
Telegraph, The, Jubilee of, 58.
Telegraphic Breakdown, The, 168, 177.
Telegraphic Communication in War Time, 191.
Telegraphs, Post Office Work in 1886, 236.
Telegraphs, Underground (Leading Article), 394.
Telegraphy, History of, Sir C. Bright's Address to Society of Telegraph-Engineers and Electricians, 219, 245.

TELEPHONE:
Circuits, Duplex, 18, 378.
House's, 88.
Limiting Distance of Speech, by W. H. Preece, 395.

TELEPHONE *(continued)*:
Sargent's, 202.
And the Sense of Hearing—New Theory, 204.
Theory of, and Hysteresis, by O. Heaviside, 302.
In the West of England, 189.

Telephonic Investigations, by S. P. Thompson, 287, 332, 372, 380.
Telephony (Leading Article), 102.
Telephony, Duplex, by A. M. Rosebrugh, 378.
Telephony, Review of Work Done in 1886, 192.
Terrestrial Magnetic Disturbances and Solar Phenomena, by H. Wild, 310.
Thermometers, Internal Capacity of, by A. W. Clayden, 43.
Thompson, S. P., His Calorific Equivalents Criticised, 457.
Thompson, S. P., Dynamo Characteristics, 111.
Thompson, S. P., Magnetite, 18.
Thompson, S. P., Telephonic Investigations, 287, 332, 372, 380.
Thomson, E., Electric Welding, 166.
Thomson, Sir W., Electrical Meters, 541.
Tomlinson, H., Effect of Increased Temperature on Iron, 267.
Tomlinson, H., Magnetic Induction, 487.
Torpedo, Lay's, 393.
Trains, Signalling Approach of, 550.
Tram Lines, Electric Conduit, 18, 419.
Tramcar, Electric, Elieson's, 256.
Tramcars, Electric, by T. C. Martin, 150, 223.
Tramway, Electric, Field's, 419.
Transformer, The Westinghouse, 459.
Transformers, Distribution by, 77, 551.
Transformers, by J. Hopkinson, 420.
Transformers, Series-wound, Regulation of, 540.
Tunzelmann, G. W. von, (*see* CONTEMPORARY PROGRESS).

U

Underground Telegraphs (Leading Article), 394.
Union Storage Cell, 190.
United Telephone Company and Long-distance Telephony (Leading Article), 564.
Unwin, W. C., New Instruments for Testing Materials, 267.
Upward Battery, New Type, 348.
Upton, A. F., Plans for Installing Central Stations, 427.

V

Vapour Pressure, Influence of Change on, by Ramsay and Young, 132.
Verdet's Law, Verification of, (*see* CONTEMPORARY PROGRESS).
Vesey's Electric Laryngoscope, 244.
Volk's Electric Railway, 260, 259.
"Volta," The, Wreck of, 521, 548, 572.

W

Walker, J., Cauchy's Theory of Light, 132.
Walker, S. F., Primary Batteries, 243, 264.
Walker's Sulphur Sal-ammoniac Cell, 213.
Waterford, Electric Lighting for, 391.
Webber, General, C.E., Incandescent Lamp Manufacture, 112, 130, 152.
Weber, C. L., Conductivity of some Alloys, 109.
Welding, Electric, by E. Thomson, 166.
Westinghouse, Transformer, The, 459.
Wild, H, Magnetic Disturbances and Solar Phenomena, 310.
Wire, Acheson's Duplex, 330.
Wire Gauge, Edison's, 330.
Wires, Overhead, and the Metropolitan Board of Works, 36.
Wires, Suspended, Resistance of, by S. Bidwell, 441.

Y

Year 1886, Review of, 192, 214, 236, 257, 304, 347.

Z

Zickler, K., Frölich's Theory of Compound Dynamos, 369, 424.

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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

No. 1.—Vol. XVIII. FRIDAY, NOVEMBER 12, 1886. Price 4d.

NOTES.

The Bath-Bristol Telephone Line.—This line was opened for public use on Monday last.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 5th inst. amounted to £3,563.

The Electric Railways of the World.—It is stated that the number of electrical railways and tramways now in existence approaches the respectable total of eighty.

Compass Errors.—We are informed that the wreck of the British steamship "Juliet," on the American coast, was due to the errors of her compass, induced by the cargo of steel rails which she carried.

Royal College of Science, Dublin.—On Friday next, Prof. W. F. Barrett commences a course of six evening lectures to working men at the above college, on "The Industrial Application of Electricity."

Cutting a Telegraph Wire.—At the Worship-street Police Court, a man named Albert Sanders was sent to gaol for three months without the option of a fine, for maliciously cutting a wire belonging to the Exchange Telegraph Company.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended Nov. 5 were £2,924, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

A Telegraphic Play.—At the Lyceum Theatre, New York, a play is now running, called "The Main Line." In one of the scenes the interior of a large telegraph office is presented on the stage, and messages are received and transmitted on Morse sounders.

The National Telephone Company.—The jurors have awarded the National Telephone Company a gold medal at the Edinburgh International Exhibition. In all probability this exhibit formed one of the most complete displays of telephonic appliances ever brought together.

Dynamo Electric Machinery.—The important paper on "Dynamo Electric Machinery," by Drs. J. and E. Hopkinson, which was read before the Royal Society on 6th May, has just been published in *Philosophical Transactions*, and we hope to reproduce it in our pages at an early date.

Telephonic Extensions in Spain.—The *Imparcial* says that telephonic communication is about to be established between the port of Motril and Salobrina, in the province of Granada, and that another line from Cangas de Tineo to Grado, in Asturias, is almost finished, and will shortly be opened for traffic.

Tenders Wanted.—Tenders for the supply of wire and telegraph instruments are asked for by the Midland Railway Company. Patterns may be inspected at the General Stores Department, Derby, and tenders will be received up to 9 a.m. on the 17th inst., addressed to the Secretary, General Stores Committee, Midland Railway, Derby.

Price of Gas in the United States.—It will be of some interest to electric lighting engineers in this country to learn that, according to a statement made at the recent meeting of the American Gas-Light Association, the lowest price charged for gas by any company in the States is 90 cents per thousand feet, and the highest $6 per thousand; the average price being $1.74 per thousand.

Communication Wanted.—At a meeting of the Brandon Local Board last week, on the suggestion of one of its members, the clerk was instructed to draw up a memorial for presentation to the Post Office authorities in support of the inhabitants of the Dearness Valley, who are just now endeavouring to get telegraphic and telephonic communication established between them and the outside world.

Spanish Tenders for Telegraph Wire.—The Madrid papers contain a notification to the effect that tenders will be received on the 6th December next at the Central Offices of the Post and Telegraph Department, Madrid, for the supply of 60 tons of galvanised iron wire, of four millimetres in diameter, required for the construction of a line from Lérida to Viella. The prices and conditions are on view at the offices in Madrid.

Electric Light at a Leeds Music Hall.—Messrs. Walsh and Co., of Leeds, have recently fitted 30 Swan 20 candle-power lamps in the lounge of the Prince's Palace Music Hall in that town. The lamps are supplied with current from a set of E.P.S. accumulators, and the latter charged over a circuit a quarter of a mile in length from a Phœnix dynamo at the works of the above-named firm in Wade-lane.

The New York Conduit.—The first wires to be actually placed in the New York conduit have been those of the Fire Telegraph system, for which 920ft of a six-wire cable have just been put in. The work of drawing in proved at first more difficult than had been anticipated, but became easier as experience was gained. It is anticipated that by the 1st of January ten miles of the conduit will have been constructed.

Elberfeld, Prussia.—The municipality of the large manufacturing town of Elberfeld have recently taken the vote of the inhabitants of the central district upon the question of establishing a public electric lighting installation. The replies have been almost unanimously in favour of the project, which will therefore be carried out. We presume that the Edison system will be adopted, as in so many other town installations upon the Continent.

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THE SOCIETY OF ARTS.—The first meeting of the one hundred and thirty-third session of the Society of Arts will be held on Wednesday, the 17th inst., when the opening address will be delivered by Capt. Douglas Galton, C.B., D.C.L., LL.D., F.R.S., chairman of the council. As arranged at present, on December 8th, a paper will be read by Major-General C. E. Webber, R.E., C.B., on "Glow Lamps, their Use and Manufacture."

A SINGULAR PROCEEDING.—We quote the following incident verbatim from a New York journal:—" The manager of a telegraph company in New Haven, Connecticut, has gained considerable notoriety by evading the law relative to the erection of poles in public streets. On Sunday, October 17th, two enormous telegraph poles, one ninety and the other eighty-three feet in height, were erected without interference. Had this been done on any other day an injunction would have been served."

MOTIVE POWER FROM ARTESIAN WELLS.—A flour mill in New Jersey is supplied with electric light by motive power derived from a turbine which is set in motion by the water of an artesian well, sunk especially for this purpose. Artesian wells have recently been sunk in several parts of London in order to render the proprietors independent of the water companies. Wherever the rise and the quantity of flow is sufficiently great, these fortunate individuals are probably in a position to provide themselves with electric light at a very low cost.

THE UNITED STATES PATENT OFFICE.—We have received a copy of the annual report of the United States Commissioners of Patents for the year 1885. This is a very bulky volume, consisting of upwards of 700 quarto pages. The greater part of the contents consists, however, of an alphabetical list giving the name, residence, and invention of each applicant for a patent. The number of applications filed during the year was 34,697, of which only 24,104 were actually granted. Of the latter number 549 were issued to citizens of this country.

THE BRIGHTON ELECTRIC LIGHT COMPANY.—We have received the report of this company's operations for the twelve months ended 30th September, 1886, which shows a profit of £516. 16s. 5d., out of which the directors recommend a dividend of 4 per cent.—requiring £289. 12s. The amount written off for depreciation is £200, the plant being given as an asset valued at £4,627. 15s. 6d., premises at £1,793. 3s. 8d., and circuit at £757. 5s. 5d. Considering these figures the depreciation seems scarcely sufficient. The second ordinary general meeting was held at the offices of the company on Wednesday, November 10th.

ALTERNATING CURRENTS IN AMERICA.—At the present time alternating currents are so little used in the States that a paragraph with the above title might almost paraphrase the famous chapter on the snakes of Iceland, which merely stated that there are no snakes in Iceland. One of our Trans-Atlantic contemporaries is, however, of opinion that alternating currents are likely to come into use more and more. From the tenor of the article it seems that our American friends have as yet scarcely realised the full extent of the differences between continuous and alternating currents, and the extreme importance of the influence of the periodic time in the latter case.

ADDITIONAL ADVANTAGES FOR TELEPHONE SUBSCRIBERS. The Telephone Exchange at Brussels has undertaken the performance of a new and important service. Such of their subscribers as may desire it are supplied with electric bells in their bed rooms, which are rung at an appointed hour in the morning by a currect from the exchange. The subscriber is bound to turn out of bed to switch off, so that the arrangement possesses some advantage over an ordinary alarum clock, which sounds only for a limited time. It is stated that most of the leading merchants in Brussels are now taking advantage of the service, and a hitherto unheard of punctuality is said to prevail in the offices of the city.

THE GOVERNMENT AND TELEPHONES.—In answer to a deputation from the Edinburgh Chamber of Commerce, on the 4th inst., Mr. Balfour, the Secretary for Scotland, said that as to telephones, he had not a matured opinion on the subject, but he entirely agreed with the objections to any monopoly being created in them which the Government might afterwards be required to purchase; but when the Government bought up the telegraph system they secured that they should have absolute control over the sending of messages by electricity, and no one was able at the present moment to establish a telephone without a Government licence, so that there was not the slightest chance of any monopoly.

BIRMINGHAM PROVISIONAL ORDER.—At a meeting of the Birmingham Town Council on the 9th inst. a report from the Town Clerk was read advising that as the Incandescent Electric Lighting Company had taken no steps under the Provisional Order granted to them in 1883 to introduce electric lighting into the town, the Board of Trade should be asked to revoke the order. The report pointed out that the company had been unable to obtain the capital required; but meanwhile they monopolise what is probably the best area in the town for electric lighting. It was agreed that the Board of Trade be asked to revoke the Provisional Order. It will be seen that the action of the Council has not been dictated by any hostility towards the electric light.

THE LOWTHER TELEPHONE.—A telephone transmitter of a somewhat novel and curious order is now being shown in Chicago. Instead of speaking directly to a diaphragm, the operator holds a sort of button connected to a flexible wire to the side of his throat while talking. In this way perfectly articulate speech is transmitted, the tone is said to be much fuller and louder than with any instruments of the diaphragm class, and the *timbre* of the voice is better preserved. Another advantage is that whatever external noises may be going on, no sound but that of the speaker himself will be transmitted. If preferred, the button may be applied to the top of the head, or indeed to any other part of the skull, but the articulation, though still clear, is not so loud. The tip of the nose is not recommended.

LONG DYNAMO RUNS.—After quoting from our columns a note as to a continuous run of twenty-eight days which was recently performed by a Kapp dynamo on board H.M.S. "Devastation," the New York *Electrical World* proceeds to cap the story as follows:—"This recalls a phenomenally long Edison run. In February, 1884, a plant was put in the Post Office, Boston, consisting of two of the first type of 250-light machines. Without any previous testing—such was the urgency of the case—they were started, and were operated continuously for ninety-seven days and nights, when the capacity of the plant was increased without any interruption in supply of current to the circuits. The supply has not ceased, either day or night, from its going into operation in February, 1884, down to the present time."

THE TELEGRAPH IN HOLLAND.—The following statistics as to the telegraph system in Holland appear in the *Journal Télégraphique*:—The total number of stations open at the end of 1885 was 595, there were 4,700 kilometres of lines, and 16,780 kilometres of wire. About one half of the total length of

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lines traverse the banks of canals and the rest is chiefly on the railways. The number of offices open is 595, of which 303, including 72 telephone stations belong to the State and the remainder to private companies. There is one telegraph office for every 9,025 inhabitants of the country. The number of instruments in use upon the State lines was 712, of which there are 530 Morse, 45 Hughes, 2 Meyer quadruplex, 2 Estienne, and 133 telephones. In the year 1885 the number of messages passing over the State lines was 3,444,698, being an increase of 123,829 over the preceding year.

ELECTRICITY IN THE CEMETERY.—We mentioned a short time since that a society had been formed at Brooklyn for the prevention of premature interment by the adoption of a system of electric alarm. It is now stated that the idea has actually been carried into practice at Sandusky, Ohio, by the following means :—Metallic rings are placed upon two adjoining fingers of the corpse in such a way that the slightest movement would bring them iuto contact, and thereby complete an electric circuit in which is placed a bell and a set of annunciators to show the number of the vault from which the signal comes. The bell is placed over the bed of the cemetery-keeper, so that he may be in instant attendance if required. This seems rather a gruesome idea (especially for the cemetery keeper), but if actually carried out on any extensive scale the experiments will be of extreme value in settling the horrible suggestions which have sometimes arisen as to the prevalence of premature burial.

ELECTRICITY AND AGRICULTURE IN RUSSIA.—The proprietor of the Russian journal, *Selsky Khosiane*, has recently made an enterprising and philanthropic attempt to bring electricity to the assistance of the struggling and distressed agriculturists of Southern Russia. It is stated that the Russian wheat growers are being absolutely ruined by American and Indian competition, and that their only chance is to thrash out their grain and place it on the market for export at the earliest possible moment. It is therefore extremely desirable that thrashing operations should be prolonged as late as possible in the evening. But to thrash by the aid of oil lamps, with loose straw all over the place, is simply to court disaster. To meet this difficulty the proprietor of the *Selsky Khosiane* has interested himself in the introduction of electric light. The Stepanoff primary battery, which is described as a modification of the Daniell, is said to have been used at Riazin with much success. Two or three lamps of 8 candle-power are found sufficient.

ELECTRIC MOTORS IN THE STATES. — A correspondent writes to an American journal as follows :—"When in New York a few days ago, I was much impressed by the large number of electric motors in use there, in connection with small manufacturing plants, elevators, and for a variety of other purposes. The enthusiasm exhibited by the users of these motors is surprising. I talked with the proprietors of a number of establishments where these clean and untroublesome little machines were doing daily work, and in every case they were not only satisfied but delighted. The dirt and bother from fuel and ashes are avoided, no expensive plant is necessary, and the work required to be done is accomplished n the most satisfactory manner possible-" We commend this paragraph to the attention of those gentlemen who have lately been interested in a scheme for the distribution of power in Birmingham, a scheme which we understand to have fallen through for the present.

LIGHTING OF A FLOUR MILL AT BOROUGHBRIDGE.—A correspondent of the *Leeds Mercury* writes :—"On Tuesday evening the flour mill of Messrs. Lofthouse and Hammond, of Boroughbridge, was thrown open to the public between the hours of six and eight o'clock, for the purpose of inspecting the working of the electric light, which has just been introduced by them into the largest of the mills, which stands on the Boroughbridge side of the River Ure. The commission has been carried out by Messrs. Christy, Son, and Norris, electrical engineers, of Chelmsford. Altogether over a mile and a half of wire has been used in the work. A Crompton dynamo of 6 horse-power is employed, and is arranged to be driven either by water or steam (both of which are in the mill). The machine runs at 800 revolutions, and supplies 50 lights of 16 candle-power, and one of 50 candle power. Messrs. Lofthouse and Hammond express the opinion that lighting by electricity is safer than gas lighting, and that the cost will only be one-third the amount per annum that gas cost them.

THE BARTHOLDI STATUE INSTALLATION.—The fifteen 6,000 candle-power arc lamps by which the statue of "Liberty Enlightening the World" is enabled to enforce the metaphor are supplied with current from an "American" dynamo, which is driven by an Armington and Sims engine, the machine being placed in a small shed at the foot of the pedestal. The dynamo runs at 870 revolutions, giving 30 amperes, at an E.M.F. of 700 volts. This is only 1,400 watts per lamp, without allowing for loss in leads, so that the arcs must have a high efficiency if they give the full nominal candle-power. The machine has an internal resistance of 3·5 ohms, and an electrical efficiency of 91·5 per cent. The total weight of the machine is 3,700lb., the armature carries 240lb. of No. 9 copper wire, and the field-magnets are wound with 640lb. of No. 5. The total electrical horse-power in circuit is 32, and 35 horse-power are required at the dynamo pulley. Duplex lamps are employed, of the "American" type. They burn Wallace copper-coated carbons, $\frac{3}{4}$in. diameter, with $\frac{1}{4}$in. arc; the E.M.F. per lamp is 38 volts, which, with 30 amperes, is equal to 0·19 watt per candle.

FLUORESCENCE FROM ELECTRIC DISCHARGE.—We recently mentioned that M. Lecoq de Boisbaudran is engaged in an investigation upon the fluorescence of different substances under the electric discharges in a vacuum. The following are some of the results which have been obtained :—Sulphate of lime, after being heated to a dull red, gives a feeble fluorescence with a continuous spectrum; but when MnO, SO_3 is added it furnishes a beautiful green tint. With $\frac{1}{100}$ part of this salt the effect is very fine and with $\frac{1}{20}$ it is superb. The spectrum is continuous, but contains little red or violet. Carbonate of lime gives fluorescence *in vacuo* after strong calcination and a violet tinge at the electrodes. With carbonate of lime, rendered manganiferous, there is an orange fluorescence after calcination; sulphate of magnesia, after being heated red a little, gives a feeble fluorescence of a greenish white, with continuous spectrum. Pure carbonate of magnesia gives no notable fluorescence after strong calcination. Similarly, carbonate of magnesia containing a little carbonate of manganese, furnishes fluorescence. Sulphate of zinc, after heating to dull red, gives a feeble fluorescence of a pale rose colour. Sulphate of cadmium, oxalate of strontium, and some other salts, also yield a fluorescence in vacuum.

TELEPHONING WITHOUT WIRES.—The problem of effecting electrical communication without the use of metallic connections has long been known to be within the limits of theoretic possibility, and indeed, it has more than once been actually accomplished. While, however, it is proverbially rash to prophecy, and more especially to attempt to assign a limit to the achievements of the future, we shall venture to assert that

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the day is far distant when electric communication without wires will become general, if only because it is obvious that the problem involves all the difficulties of multiplex telegraphy on the most gigantic scale. Prof. Dolbear has, however, designed an arrangement for telephoning between two given points without wire, and states that it can be successfully employed over distances exceeding half a mile. His plan amounts to this: A condenser at one station is charged from a battery in the circuit of which a telephone transmitter is included; one pole of battery is connected to earth, and one pole of the condenser remains free and disconnected, so that the battery, which should contain at least 100 cells, is really on open circuit. A similar arrangement exists at the other end of the line, only that in the circuit in which the receiver is placed the opposite pole of the battery is connected to earth. When the transmitter is spoken to, the disturbance of the potential of the earthplate is sufficiently marked to affect the receiver at the distant end. From a practical point of view, a serious difficulty would arise from the inability to transmit a call signal on this system.

Evening Lectures at the Finsbury Technical College. We have pleasure in calling attention to the following circular: The following course of instruction has been arranged to meet the wants of machinists, ironmongers, bicycle makers, lamp makers, electroplaters, and others who desire to obtain theoretical and practical knowledge of the processes of electro-deposition of metals. The six lectures of this course will be delivered by Prof. Silvanus P. Thompson, on Thursdays, at 8 p.m., at the Finsbury Technical College, commencing Thursday, 8th of November, 1886. This course of lectures is devoted to the modern practical processes of nickel-plating, steel-plating, coppering, electrobrassing, electroplating with silver, electro-gilding, &c. Special attention is paid to the use, in plating, of the dynamo-electric machine. A course of practical laboratory instruction is provided as supplementary to the lectures, under the superintendence of Mr. E. Rousseau, and the demonstrators of the electrical department. Students entering for this course will be divided into groups, each group receiving independent instruction:—I. November 18th, "General Principles of Electro-chemical Deposition; Fundamental Experiments on Electrotyping and Electroplating." II. November 25th, "General Principles of Electric Currents; use of Galvanometers." III. December 2nd, "Electro-deposition of Copper; Electrotyping; Silver-plating; Electrobrassing; Electro-gilding." IV. December 9th, "Nickel-plating; Steel-plating; Deposition of Cobalt and of Aluminium." V. December 16th, "Preparation and Testing of Plating Solutions." VI. December 23rd, "Dynamo-machines for Electro-deposition." We may add that the fee for this course, including laboratory instruction, is only 6s., while apprentices are admitted at half fees.

A Magnificent Idea.—The paragraph which we reproduce below appears in a north country paper. As the gentleman referred to may be assumed to take an intelligent interest in electrical matters, it follows with a high degree of probability that he will be a reader of *The Electrician.* We therefore take the earliest opportunity of doing Mr. Quarrie the greatest service in our power, and beg to assure him that in our own opinion—which he may take for what it may be worth—some of his ideas are scarcely in accordance with the generally received views as to sound and practical electrical engineering. "Mr. George Quarrie has invented certain improved apparatus designed for the production of electricity. His plan is to utilise rotating shafts in mills and steamboats, railways and tramcars, upon which to affix generators which will throughout the day be ceaselessly collecting and storing electricity for use when darkness comes on. He further proposes to utilise the two natural forces of wind and moving waters to produce a continuous flow of the electric current, on the principle of Faraday's discovery that if a magnet is dipped just inside a coil of copper wire, and suddenly withdrawn, a current of electricity is generated. For the supply of a city or town the streets will be crossed by minute rails, whose vibration by the crossing traffic would be a large source of the current in the same way; (!!) and the inventor considers it possible to supply every house and street of town and country with all the light they want at a cost of a very small fraction of that paid for anything now in the market for that purpose. It is stated that one large factory and a steamship company have arranged with Mr. Quarrie to have the system immediately adopted in the works and in one steamship as practical trials."

The Electric Light at Tavistock.—The *Western Morning News* of Nov. 6th contains the following paragraph with reference to the Thomson-Houston installation, which Messrs. Laing, Wharton, and Down have recently established at Tavistock:—"The electric light as exhibited at Tavistock during the past week has proved a signal success, and has been nightly watched by large and interested crowds. Yesterday being market day, large numbers of persons from the country places remained in town for the purpose of seeing what the illuminations were like, and were well satisfied with the results shown by the proprietors, who went through a series of experiments in lighting and turning off the light and then relighting. There are now eleven arc lamps in various parts of the town, and they are all giving a splendid illumination. Arrangements were being made yesterday (Nov. 5) for lighting the parish church on Sunday evening next, the wires having been already carried into the edifice for that purpose. The shop of Messrs. Cundell and Camozzi, of Duke-street, was also illuminated last evening with marked success, and large numbers of persons witnessed the experiments of Mr. Cundell in turning out and again producing the light. On Sunday, the 14th, the Congregational Church is to be illuminated, and various shops will also be lighted during the coming week. Mr. Wharton will shortly lecture in the Town Hall on the advantages of the electric light, and will then explain and show how easily it may be used. The hall will be lighted by electricity on the occasion." We trust that the good people of Tavistock will have the enterprise to seize the opportunity of distinction which is now offered them, and will arrange with Messrs. Laing, Wharton, and Down for a continuance of the "experiments of turning in and out the light" every night in perpetuity.

The Distribution of Power.—The following are the views of a Boston (U.S.) manufacturer on this subject. To a certain extent the statements must no doubt be taken *cum grano salis*, but they are probably not very far wrong:—"The transmission of power from small central stations for small distances by means of wire ropes, shafting, &c., has been done for years, and so profitable has it been found to be that many of the wealthiest and shrewdest business men in Boston have been engaged in it. Steam plants of 50 or 75 horse-power have been placed in many blocks to furnish power for elevators, pumps, fans, and machinery, and the power is sold at the rate of $150 per horse-power per year; in many cases a higher rate is obtained. I have investigated the subject, and find that electric current, as sold for lighting purposes, is charged at the rate of $300 per horse-power per year; while from the same stations the rate for electric-motors is $125 per year per horse-power. As the use of the motor is by no means constant, double the amount of power can be sold; that is, the capacity of the station. Here is the estimated cost and profit of a power

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station :—160 horse-power boilers, 140 horse-power in engines, 2 dynamos capable of generating current equivalent to 100,000 watts, wires, &c., $17,000. Two hundred and eighty horse-power may be sold, as is shown by experience of those renting steam-power. There is no expense for motors, as each user owns his own. Income from rental of power, $125 × 280 = $35,000, running expenses, say, $8,000, leaving a profit of $27,000, which is more than 150 per cent. on cost of plant If the station furnished current for lighting purposes during the evening, the percentage of profit could be largely increased. Burning cheap fuel under the best conditions, $15 can be made to buy enough coal for one horse-power per year. An electric method of transmitting power has the great advantage that points twenty times as distant from the source of power can be reached as when belts, ropes, shafting, are used. Four hundred times the area can be profitably covered by an electric system as by a steam plant. Wire ropes, belts, &c., are expensive, and wear rapidly. The copper conductor suffers no depreciation whatever."

A STEP IN THE RIGHT DIRECTION.—The United Telephone Company have at last determined upon a step which will go far to remove from their shoulders the reproach of lack of enterprise which has long rested upon them. They are now actively engaged in canvassing the district of Kensington, with a view to the establishment of a local exchange upon the American plan of a telephonic syndicate. The idea will be understood from a perusal of the following circulars, which we quote *verbatim*. The first is issued to the tradesmen of the district, as follows:—"Sir: The immense success which has attended the system of local telephonic exchanges in America has led the directors of the United Telephone Company to sanction an experiment in this direction at Kensington. It is proposed to connect a number of the principal residences—say one hundred—with a local exchange, and to allow the tradesmen in the district to use the system for a payment of £1 per annum for each house, and £1 extra should the amount of orders by telephone from any one house exceed £100 in the year. The saving in the annual working expenses of your business will be great, irrespective of the large accessions of business which you will receive for a merely nominal payment *(less than three farthings a day)*. Should you be disposed to join the *first* syndicate now in course of formation, I shall be glad if you will fill in the enclosed form with the addresses of any private residences with which you would like to have telephonic communication." The second is issued to private residences, and reads as follows:—"Sir: The directors of the United Telephone Company having sanctioned the establishment of a local exchange in Kensington for the purpose of connecting first-class residences with the local tradesmen, I shall be happy to receive from you, should you desire to have such telephonic communication, the annexed form filled up with the names of those tradesmen with whom you would wish to be in communication. It is not intended that you should be put to any expense, as the company will place the instruments in private residences free of all charge to the occupiers. The residents will thus be placed in instant communication with any tradesman on the list, as well as with their medical man, chemist, &c., so that assistance in case of illness or accident can be summoned without delay. The inmates of any of the private residences connected with the exchange will also be able to converse with any of their friends whose houses are similarly connected, and will also be able to call a cab from the nearest cab stand, or give an alarm to the fire and police office of their district." Here follows a list of trades—the butcher, the baker, the candlestick maker, and so forth, against which the names of the firms with whom connection is desired are to be filled in. We congratulate the residents of the Kensington district upon their good fortune. We only hope that the result may prove so satisfactory to the company as to induce them to extend the system all over the suburban districts. We do not, however, quite understand the financial side of the question. If each of the tradesmen is to pay £1 upon every connection made, the company will realise a very substantial revenue.

TELEPHONIC SYNDICATES.—The following appeared in the *Western Morning News* last week:—"'I have been asked to join a telephonic syndicate, and I want to know what it is?' Thus inquired a friend of mine the other day. Now, I do not know much about syndicates generally, except that some men who suddenly rise from mediocrity to opulence tell me they have joined a syndicate and made a nice pile out of it. But a 'telephonic syndicate' I do know a little about, and as my friend is very likely to be only one of many who thirst for knowledge, I will try to explain the sort of thing he has been asked to join. 'Shopping' is one of the wearisome institutions of civilisation. I often want some article or another, and yet for weeks leave the shop unvisited simply because to a busy man like myself time is so valuable. So much for me. But my wife? Butcher, baker, poulterer, greengrocer, fishmonger, dairyman, and I know not how many more, call for orders every day, and all the morning is spent in answering the maid, who comes to say, 'Please, 'm, the butcher,' or 'Please, 'm, the greengrocer.' If my wife can order by telephone, the tradesman is relieved of the expense of sending for orders, and hers and the maid's time is saved. What a blessing it would be! Good. But a telephone costs £20 a year. Here comes the agent of 'a syndicate,' or association of the sharp tradesmen in my neighbourhood, and says that a telephone will be fitted up if I will give—what? My permission! These traders find it so much to their advantage to have orders by telephone and save time, that they have united to furnish a hundred houses in the district with the time-saving instrument gratis. On the telephone hangs a card, and on the card are printed about twenty tradesmen's names, who form the syndicate. Finn the fishmonger, Jones the baker, and all the other leading men, the sharp, shrewd fellows who know the innate laziness of the Briton's constitution, and by saving me trouble, gain trade for themselves, here they are, set down in order, and without stirring from the house, we can command an army of ready caterers. In cases of interesting domestic emergency, or of accident, there are the doctor and the chemist on the list. Nor is this all. I have a cold, perhaps, and cannot go to town. Here is the rub. This telephone is on a small 'primary exchange,' and how can I call to 7,654, for instance, on another exchange? The local syndicate give me their instrument, but it is obvious that for me to call someone not connected with the syndicate entails expense. Very well. All that is arranged, I call my local exchange, they switch me on to the trunk line, and so to 7,654, my town office, and debit me with threepence for the message—not of twenty words, but of whatever length may suffice for the business in hand. The syndicate pays well. What the traders pay is not, be it well observed, an actual outlay, but really only a commission on orders received by telephone. In my friend's neighbourhood several firms have expressed their willingness to pay 5 per cent. on such orders. Telephone enterprise is old enough to be secure from idle opposition and the effects of panic, and yet quite young enough to show fine promise of a grand future. So, my advice to my friend, was 'join the syndicate.' It is beyond all question a capital idea, and its successful adoption in many parts is encouragement to the sharp tradesmen in all localities to follow the lead, to oblige their customers and to fill their own pockets."

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

MAGNETISM AND ELECTRO-MAGNETISM.—I.

The property possessed by the natural magnet or lodestone of setting itself in a definite direction when freely suspended appears to have been known in very early times by the Chinese and Egyptians. The word magnet was applied to the lodestone on account of its being found in Magnesia. There are two districts known as Magnesia, one in Lydia and the other in Thessaly. It is from the former that the magnet appears to have derived its name.

The power of the lodestone of attracting pieces of iron was known in Europe in early historic times, and Lucretius found that the attraction was exerted through brass as readily as through air. The tendency of the lodestone to set in a definite direction was not known in Europe till a much later date.

If a piece of lodestone be dipped into iron filings, it will be found that the filings will cling in tufts to the lodestone, and that these tufts will be largest around two regions of the surface. If the lodestone be suspended so that it can turn freely in a horizontal plane, it will place itself so that one of these regions is directed nearly to the north and the other to the south. These regions were called by Gilbert the poles of the magnet, and a line joining the poles he called the magnetic axis. That pole which points towards the north we shall call the north pole, and that which points towards the south the south pole. According to this nomenclature the magnetic pole of the earth in the neighbourhood of the geographical south pole is a magnetic north pole, and those in the neighbourhood of the geographical north pole are magnetic south poles. To avoid this apparent anachronism some persons speak of the north-seeking pole and the south-seeking pole. Others call the north-seeking pole the magnetic south pole, while others again employ terms of a purely arbitrary character to distinguish the poles, as, for instance, the red and blue, calling the north-seeking pole the red pole and the south-seeking pole the blue pole. Sometimes the magnetic pole, which is of the same kind as the south pole of the earth, is called the Austral pole, while that which resembles the earth's north pole is called the Boreal pole.

If a steel bar be rubbed with a lodestone, it will generally be found that the bar has acquired magnetic properties, and if freely suspended will set with one end pointing towards the north, and the other towards the south. If the bar were drawn across the north pole of the lodestone, that end of the bar which was last in contact with the lodestone would be a south pole. The steel bar so magnetised will be found capable of imparting magnetism to another bar, if the other bar be drawn across one of its poles several times, but always in the same direction. In this way magnets may be multiplied indefinitely.

Suppose a bar of soft iron to be placed with one end near to the north pole of a steel magnet or a lodestone. The iron bar will be found capable of attracting small pieces of iron at each end. In fact, the bar is converted into a temporary magnet, by influence, or induction. If the soft iron bar be removed from the presence of the magnet, it will be found to have lost nearly all the magnetism which was imparted to it.

If a bar of hard iron or of steel be employed, instead of the soft iron bar, the magnetism induced is much less, but if the bar be hammered, or in any other way violently shaken, while under the induction of the magnet, the bar will become permanently magnetised. The property in virtue of which hard iron or steel resists the magnetising influence of a neighbouring magnet is sometimes called coercive or coercitive force, and this same property enables the steel to retain its state of magnetism after the magnetising force has been removed.

The magnetisation of a steel bar by drawing it across a pole of a magnet is a phenomenon of magnetic induction in which the induced magnetism is rendered permanent by "coercive force."

It has been found possible to retain a very high degree of magnetisation in soft iron by treating it with sufficient care. A very slight amount of mechanical violence after the magnetising force has been removed causes the iron to lose nearly all its magnetisation. Assuming that magnetisation means a displacement of the molecules of the substance, it would seem that this elasticity of the material tended to bring them back to their original positions, and the act of magnetisation consisted in the production of an elastic strain. In very soft iron the displacement of the particles is resisted almost solely by the elasticity of the material, but in harder metal and in steel there is a very great resistance to the relative motion of the molecules, of the nature of friction, and this frictional resistance is greater the harder the metal. As is always the case with friction, the tendency of this "coercive force" is to resist change of state of any kind, and therefore to make it more difficult, on the one hand, for the magnetising force to induce magnetisation in the metal, and, on the other hand, for the elastic forces to destroy that condition when the magnetising force has been removed. If the magnetising force is very great the state of strain induced may also be very great, and when the external force is removed the elastic stress will be far more than sufficient to overcome the frictional resistance, and the material will return partly towards its original state, so that for a given material there will be a certain degree of magnetisation which it will be able to retain, and, however strong the induced magnetisation, that permanently retained will not exceed this limit. But if the material is subject to mechanical violence a new action comes into play. Place a small body upon a board and slightly slope the board, so that the body is retained on the inclined plane by friction. If not subject to vibration the body will remain at rest indefinitely; but if the board be struck lightly with a hammer the body will gradually creep down the plane. In all experimental illustrations of the elementary principles of statics friction interferes very much with the accuracy of the results unless proper precautions are taken; but by subjecting the system to vibrations gradually diminishing in intensity it will at length assume the same condition as if no friction acted upon it, and the relations between "the power and the weight" may thus, in many cases, be accurately obtained. Vibrations if sufficiently intense to relieve for an instant the normal pressure between surfaces in contact will, when constantly repeated, produce the same effect as the complete removal of the friction. It is for this reason that lock nuts are required in machinery, though the necessity for their use may be obviated when the pressure of the nut on the screw can be made so great that no vibration to which the part is exposed can release it. The same principles apply to magnetisation. If, while under the action of the magnetising force, the metal is lightly tapped, the effect is to diminish the influence of the coercive force and to enable magnetisation to be induced. On the removal of the magnetising force similar vibrations give full play to the elastic forces, and cause the metal to resume its normal state, so that steel magnets should be protected as far as possible from mechanical violence. The vibrations to which iron ships are subjected while on the stocks cause them to assume a permanent state of magnetisation through the influence of the earth, and to this permanent magnetisation is added any temporary magnetisation which may subsequently be induced in the structure.

The nature of coercive force explains the necessity of causing the steel bar which is to be magnetised to move over the pole of the inducing magnet, or to cause the pole of the magnet to move over the bar. By this means each portion of the bar in succession is brought into close contiguity with the pole, and therefore into a very intense field of force. The coercive force is thus overcome, and the molecules made to obey the magnetising force, and this action takes place in each section of the bar in succession. That the act of magnetisation consists in the displacement of the molecules is rendered probable by the observed fact that an iron bar when magnetised expands in the direction of its magnetisation and contracts laterally, provided it is not exposed to severe tension. By simultaneously magnetising a tube longitudinally and circumferentially a torsional strain can be induced in the tube. If an electro-magnet be introduced into the circuit of an alternating current dynamo, the alternate magnetisation and demagnetisation of the iron cores cause them to emit a loud musical note, due to their

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expansion and contraction. With a dynamo whose currents alternate two or three hundred times in a second, it is perfectly safe to introduce a large electro-magnet of very small resistance into the circuit, without any other resistance, for the "self-induction" of the magnet, a property to be explained later on, will effectually prevent the currents from rising above a very small limit.

If a steel bar, magnetised in the direction of its length, be plunged in iron filings, the filings will cling to the bar, mainly around its ends. At the middle of the bar there will be no attraction exerted upon the filings. If two bar magnets be brought near to one another, they will act as though the whole of their magnetism were concentrated at points very near the ends of the bars. Thus, the action of a magnet upon another magnet at a distance is very nearly the same as if its magnetism were concentrated at two points near its ends. These two points are the magnetic poles.

The accompanying cut shows the arrangement of the filings around a bar magnet (Fig. 1).

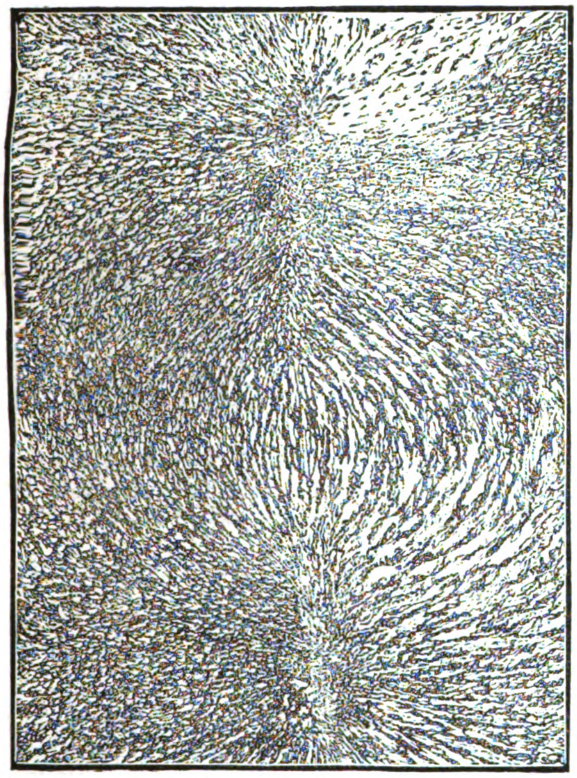

Fig. 1.

Fig. 2 shows the lines of filings near two attracting poles, Fig. 3 the lines near two poles which are repelling one another. If we suppose a tension to be exerted along the lines of filings, and a pressure at right angles to these lines, the diagrams at once indicate the nature of the stresses.

If it were possible to magnetise a bar uniformly throughout its whole length the poles would be found situated on the end faces of the bar, and no lines of filings would adhere to the bar except at its ends. It is not possible, however, to produce such uniform magnetisation, and we consequently find north polarity extending over one half of a bar magnet, and south polarity over the other half, the centre of the bar being the only neutral position; but the polarity diminishes rapidly as the centre is approached, and is generally very feeble at points more than one-third of the length of the bar from each end. This is well shown in Fig. 1, for polarity exists wherever lines of force enter or leave the bar.

If an elongated conductor be exposed to the inductive action of an electrified body placed near one end, the conductor will be charged at the one end with negative and at the other end with positive electricity, and there will be a neutral line, or line of no electrification, near the middle of the conductor. If the conductor be divided along this neutral line and the parts separated, one end will be found negatively charged and the other positively charged. But if a bar magnet be divided across its neutral line, the two parts will not be found to be oppositely magnetised, the one consisting of a north pole only, and the other of a south pole, but each portion will be found to be a perfect magnet, having its poles in the directions

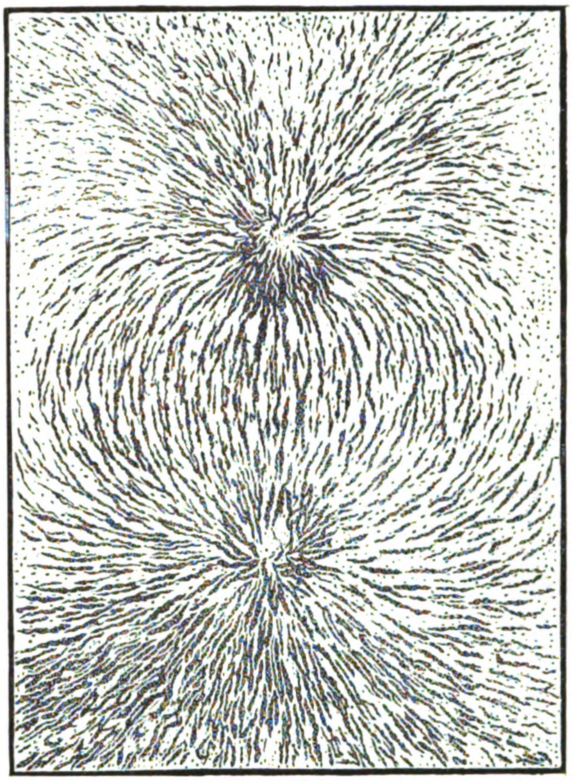

Fig. 2.

of the poles of the original magnet, and nearly equal to them in strength.

Similarly, if a bar of soft iron be placed with one end near a pole of a magnet it will become magnetised by induction, its

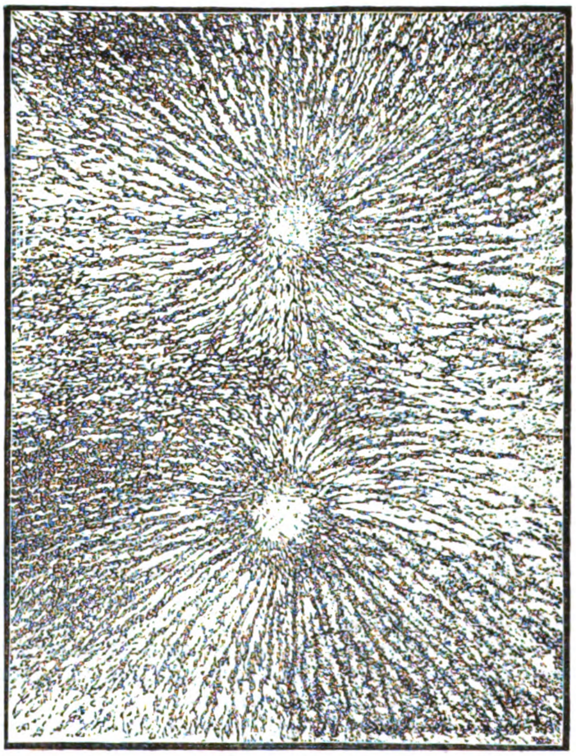

Fig. 3.

two ends being opposite poles, but if the bar, while still under the action of the magnet, be divided across the middle and the parts separated by a small distance, each part will be found to be a complete magnet with opposite poles, and will remain such

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as long as it is under the inducing action of the permanent magnet. It will be noticed that the pole in the iron bar which is nearest to the inducing pole will be less spread over the surface of the bar than the other poles, or the magnetism will appear to be more concentrated at that pole.

Fig. 4 represents the arrangement of filings around a bar of soft iron when acted on by the pole of a magnet. It should be noticed how the piece of iron appears to draw the lines of force of the magnet towards itself, and how these lines after entering the iron at the end near the magnet leave it again at the sides and at the other end. The poles of the piece of iron correspond to the portions of the surface where the lines of force enter or leave it.

To account for the invariable occurrence of opposite poles, it has been supposed that every particle of a piece of iron or steel is itself a magnet, having north and south poles, but that when the metal is in the ordinary, unmagnetised condition the magnetic axes of the particles point in all directions. The operation of magnetisation consists in imparting to the magnetic axes a general inclination towards one direction,

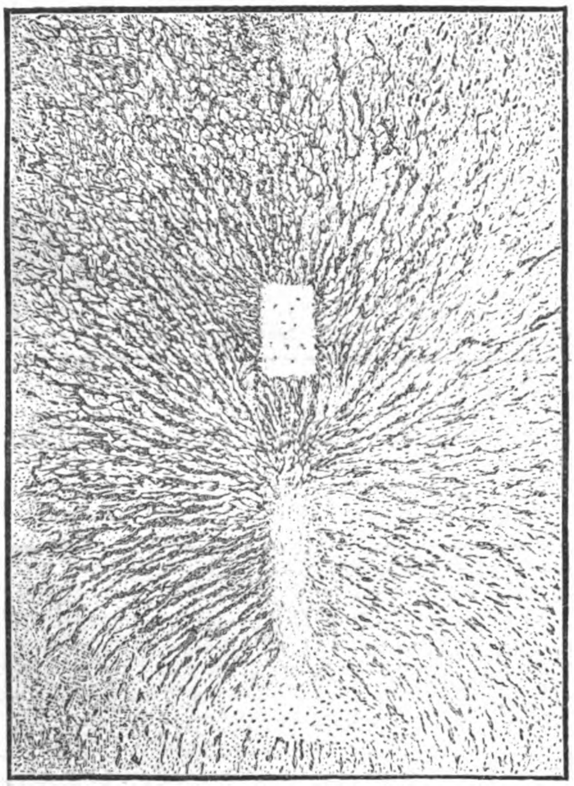

Fig. 4.

which is that of the magnetic axis of the whole magnet. If the particles are turned so that they all have their axes parallel, the metal is magnetised to the fullest extent to which it can attain. In general the magnetic axes are not all parallel, but simply have a tendency towards one direction. This theory is illustrated by taking a tube of glass, or some other non-magnetic substance, and filling it with iron filings. If the tube be now drawn across a pole of a magnet it will be found to be magnetised, just as if it were a solid bar (though less strongly). If the filings now be turned out and then replaced, the tube will show no trace of magnetisation, for the magnetised particles will have their axes turned at random in all directions.

Two magnets behave towards one another as though their poles were centres of force. The law of magnetic action is similar to that of electrical action, viz.:—

Like poles repel, and unlike poles attract one another with forces which are directly proportional to the product of the strengths of the poles, and inversely proportional to the square of the distance between them.

From this law the action of one magnet upon another can be determined by calculation.

(To be continued.)

TESTING DYNAMO MACHINES.

BY JAS. SWINBURNE.

Introductory.

In the discussion upon the paper by Mr. Kapp at the Institution of Civil Engineers last November, Dr. Hopkinson proposed a method of testing dynamo machines that reduced the error due to the inaccuracy of mechanical dynamometers. Dr. Hopkinson has since worked the system out very thoroughly, and has thus put electrical engineers in possession of a most valuable means of measuring the efficiency of dynamos. Dr. Hopkinson's method has been very fully described in the various technical journals, so it is enough to say that it consists in coupling a dynamo and a motor together rigidly, and connecting them together electrically also, so that the mechanical power given to the dynamo by the motor is partly returned as electrical power to the motor. The loss of power in both machines is made up by supplying mechanical power by a belt from a small subsidiary motor. This power is measured by a dynamometer, and as it is only a small fraction of the whole power a slight error in this determination becomes very small in comparison with the whole power transmitted by the large motor. The publication of the tests of the machines at Messrs. Mather and Platt's works brought out the fact that Captain Cardew had already been in the habit of testing dynamos and motors by a method similar in principle to Dr. Hopkinson's, with the advantage of dispensing with all mechanical dynamometric readings. Captain Cardew coupled a dynamo and motor together by a belt, and fed the motor entirely from an outside source, and ran the dynamo into resistance. This method is capable of great accuracy in measurements, but it has the drawback of needing three large dynamos to make a test, and this is not always easy to arrange. Captain Cardew does not seem to have realised that his system was capable of such great perfection, and appears to have merely measured the loss of power electrically, and to have split it between the two machines. Captain Cardew's method will be more fully described in connection with some tests recently carried out at Enfield Ordnance Factory.

About the time of the Manchester tests the writer discussed with Mr. Crompton various ways of modifying Dr. Hopkinson's method, so as to get accurate tests without the use of a mechanical dynamometer and without waste of power, by coupling the motor and dynamo together both electrically and mechanically, and supplying the loss of power electrically, so that all the measurements should be electrical. This method was brought before the Dynamicables or mentioned there very soon after, by Mr. Crompton. Lord Rayleigh immediately afterwards suggested that this might be done, and Captain Cardew drew attention to his method at the same time. Messrs. Menges, Trotter, Haynes, and others have since proposed various arrangements, and as the subject is very important it may be as well to discuss several ways of taking tests with different means at command. The writer has not any large array of experiments to produce, but his object is to explain various methods of taking efficiency tests, so that many engineers who have not two or three large dynamos at hand, and possess no transmission dynamometers or accurate measuring instruments, may be enabled to find out the value of their machines.

Before going into the details of actual testing a few words must be said on the reversibility of dynamo machines. Last winter Mr. Mordey pointed out in the *Philosophical Magazine* that the common idea that a good dynamo is a bad motor, and a good motor a bad dynamo, is wrong, and that the principle of design is exactly the same in each case. That it is so, and must be so, is obvious immediately one has his attention drawn to the point, for it is clear that if it takes a certain force to move a conductor through a given field, there is the same force available to move the conductor in an opposite direction. Mr. Mordey's theory is, like many similar things, so clear when one understands it that one thinks he has known it all the time. No doubt every electrician who read that article felt as if there was nothing new in it, though it is

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really one of the most important papers that has recently appeared. But, on the other hand, there are a great many people who still think a motor ought to have much more wire on the armature, and a comparatively weak field. This, perhaps, arises from some confusion as to dynamos and motors designed to have a high efficiency, or a very light weight. A dynamo, or motor, designed to have a high efficiency is made with a strong field, and comparatively little wire on the armature. Such a machine is heavy, and consists chiefly of iron. If a dynamo or motor is wanted particularly light, it is made with a small field, and more copper is wound, both on the field-magnets and on the armature. The result is that a machine is obtained which gives a large output for its weight, but has not such a high efficiency, and needs more copper. Moreover, it is liable to spark, and its brushes need to be carefully attended to if the load is varied. But in each case the design for the motor and for the machine is precisely the same. It has been said that a motor differs from a dynamo with regard to the action of its armature on the field-magnets. An analogy has been said to exist between the revolving armature and the keeper of a permanent magnet. If the keeper of a permanent magnet be quickly removed, a current is induced round the magnet, tending to strengthen it, and if quickly brought back the reverse takes place. A motor has therefore been compared to a magnet with its keeper always approaching, and a dynamo to a magnet with its keeper always being torn away. The analogy, however, breaks down completely, for though the iron of the armature moves round in the case of a machine, the field in it is stationary. There is, therefore, no such action on the field-magnets. In 1883 the writer, after seeing some articles in the French journals which assumed a back electromotive force in the field-magnets, tried the following experiment :—A small Siemens direct current machine was run, with only one magnet excited, and its full armature current. A galvanometer was put in circuit with the other two coils. There was no deflection. So close is the correspondence between a dynamo and motor that even the lead of the brushes to avoid sparking, due to self-induction, corresponds. A dynamo demands an extra forward lead, and a motor an exactly equal extra lead in the other direction.

It is very important that these points should be clearly understood, for the common misapprehension has been the cause of the manufacture and sale of a large number of very bad motors in this country, and more especially in America. When anybody wants a good dynamo he goes to some maker who has studied the subject, and who, from his experience and standing, can be relied upon to make a good machine ; but when a motor is wanted it seems to be assumed that a dynamo maker cannot make it, and someone who is supposed to have made a speciality of motors is got to fabricate a machine. Any manufacturer who makes a good efficient dynamo can make an equally good efficient motor, and those makers who have worked out good types of light-weight ship machines can without further experiments make good light-weight motors. The practice of making very bad machines of extraordinary and outrageous design, on the supposition that they are therefore good motors, prevails chiefly in America, but it is not unknown in this country, and is much to be discouraged. The apparent efficiency of a motor is higher than that of a dynamo. This results merely from the way of taking efficiencies, just as 10 per cent. discount is a larger share than 10 per cent. interest. Take, for example, a series wound machine which as a dynamo gives 100 volts at the terminals, and say 746 amperes at a certain speed. Suppose there is a loss of 15 volts in the armature and field-magnets, and that the other small losses are neglected, the machine then gives out 100 electrical horse-power, and absorbs 115 horse-power at the belt. The electromotive force of the armature is 115 volts, of which 15 are lost in the machine itself and 100 given out. The efficiency of the machine is 87 per cent. as a dynamo at that speed and with that current. Suppose the machine is run as a motor at the same speed with the same current. The back electromotive force of the armature is then 115 volts, and 15 more volts are needed to overcome the resistance of the wire. The machine therefore needs 130 volts on the terminals, and it will give at the pulley, with a current of 746 amperes, 115 horse-power, which is just what it absorbed as a dynamo. Its efficiency as a motor will be 88·5 per cent. With a less efficient machine the difference would be greater.

To test a dynamo thoroughly we want to know not only the output and the efficiency, but also the exact loss of power in each part of the machine.

The whole loss is made up of the losses due to the following :—

1. Mechanical friction of the bearings, &c.
2. Foucault currents in the armature core.
3. Persistent magnetism in the armature.
4. Foucault currents in the armature conductor.
5. Resistance of the armature conductor.
6. Resistance of the field conductors.
7. Foucault currents in the field-magnets.

Most of these losses can be separately estimated. The loss in overcoming the resistance of the armature and field-magnets, for instance. can be calculated at once, but the losses by Foucault currents in the armature, core and spindle, &c., by persistent magnetism in the armature core, and by Foucault currents in the armature conductor, are more difficult to get by themselves. The effect of persistent magnetism, or, as it is sometimes called, residual magnetism or hysteresis, in the armature core, does not appear to have been much studied ; but persistent magnetism plays a far more important part in dynamos than is commonly supposed. As Lord Rayleigh remarks, it is generally confused with Foucault currents, but its existence in the armature, apart from Foucault currents, may easily be shown. If the armature of a dynamo which runs very freely be rotated by hand without the field-magnets being excited, it runs round very easily. If, while it is running round, the field is suddenly separately excited the armature is pulled up sharp. It is now found to take some force to move it round in either direction. If it is given a shove round it will quickly stop and give a kick back in the opposite direction. This effect can be due to persistent magnetism alone, for Foucault currents would not be perceptible at such a slow speed, and nothing but persistent magnetism would give the kick in the opposite direction. The Foucault currents in the armature wire cannot be separately measured. A Foucault current is a current induced where it is not wanted. In large machines these currents constitute a very important loss of power. Though they cannot be measured directly, a minimum value for a given machine may be roughly calculated, and by exploring the field by means of a pilot brush enough data may be obtained to calculate the loss very approximately. Loss of power through Foucault currents in the field-magnets is a common fault in arc light machines. There are two ways of losing power by Foucault currents in the field-magnets. One is by using an armature with teeth, such as the various modifications of the Pacinotti ring; and the larger the teeth the more serious is the waste. In such a machine, for instance, as the Brush, the pole pieces become so hot that the paint gets burnt off. As Dr. Hopkinson points out, the heating would be even more serious if the pole pieces were made of soft iron, which would offer less electrical resistance. The other source of loss of power in the fields by Foucault currents is due to unsteady currents. This, again, is generally confined to arc machines. Such armatures as the Brush or Thomson-Houston tend to give a varying current. The variation is partly corrected by the self-induction of the field-magnets and of the lamps or other appliances in the outer circuit. The self-induction of the field is lessened by persistent magnetism. Prof. E. Thomson describes the use of a layer of copper strip or wire wound on the magnets under the existing coils so as to form a closed circuit. This lessens the waste of heat, for any change in the main current produces a current in this wire which tends to keep the induction in the magnets uniform. In the case of a series dynamo the loss of heat, including that due to the current round this closed copper circuit, is less than the loss in the iron alone without it. The loss in the field-magnets with an unsteady current cannot

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of course be found by taking the current with an ordinary ammeter and multiplying its square by the resistance of the field-magnets. It can be integrated, however, by a high resistance Weber dynamometer, without self-induction, used as a watt-meter. Foucault currents in the field-magnets are chiefly to be met with in arc machines, especially in those from the other side of the water. They may arise, however, from the arc lamps themselves, in which case they must be considered a fault in the system, not in the machine.

(To be continued.)

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXIII.

BY OLIVER HEAVISIDE.

(Continued from page 317, Vol. XVII.*)*

The Equations of Propagation.—Introduction of Self-Induction.

The next step to a correct formulation of the laws of propagation along wires is obviously to take account of the electric force of inertia in the expression of Ohm's law. This appears to have been first attempted by Kirchhoff in 1857. According to J. J. Thomson ("Electrical Theories," *The Electrician*, June 25, 1886, p. 138) this was his system. Let

$$e = \mathrm{X} \sin ns,$$

where e is the charge per unit length, and s is length measured along the wire. The equation of X is

$$\frac{c^2}{2}\frac{d^2\mathrm{X}}{ds^2} = \frac{rc^2}{16l\gamma}\frac{d\mathrm{X}}{dt} + \frac{d^2\mathrm{X}}{dt^2},$$

where r is the resistance of the wire in electrostatic units, l its length, $\gamma = \log(l/a)$, where a is its radius, and c is a quantity occurring in Weber's hypothesis, the velocity with which two particles of electricity must move in order that the electrostatic repulsion and the electromagnetic attraction may balance.

As it stands, I can make neither head nor tail of it. But, by extensive alterations, it may be converted to something intelligible. Turn X into e, in the second equation; or, what will come to the same thing, take V as the variable, since e and V are proportional. Then ignore the first equation altogether. Turn s into our variable x. Then

$$\frac{d^2\mathrm{V}}{dx^2} = \frac{r}{8l\gamma}\frac{d\mathrm{V}}{dt} + \frac{2}{c^2}\frac{d^2\mathrm{V}}{dt^2}.$$

Clearly this should reduce to (71*b*) by ignoring the last term. Therefore

$$r/8l\gamma = \mathrm{RS}.$$

Here r/l is the resistance per unit length. Therefore $(8\gamma)^{-1}$ should be the capacity per unit length, or $\{8 \log (l/a)\}^{-1}$. This is clearly wrong. The l should be a_2, the distance of the return, a far smaller quantity than l; and the 8 should be 2, if the dielectric is air. This last correction may, however, be merely required by a change of units. Making it, we get this result

$$\frac{d^2\mathrm{V}}{dx^2} = \mathrm{RS}\frac{d\mathrm{V}}{dt} + \mathrm{L_0S}\frac{d^2\mathrm{V}}{dt^2},$$

in our previous notation, with the addition that $\mathrm{L_0}$ is the inductance per unit length of the dielectric only. That is,

$$\mathrm{L_0} = 2\mu \log (a_2/a_1),$$

with unit inductivity; a_2 distance of return, a_1 radius of wire. This estimate of the inductance is, of course, too low. The change of units makes it doubtful whether $\mathrm{L_0}$ or some multiple of it was meant, but it is clearly a wrong estimate. Notice that $\mathrm{L_0S}$ is the reciprocal of the square of a velocity, which is numerically equal to the ratio of the electromagnetic and electrostatic units, and is the velocity of light, or close to it.

It is clear that there is room for considerable improvement here in several ways, such as the establishment of the equations independently of such a very special hypothesis as Weber's; also in the estimation of L; and, in interpretation, to modernise it in accordance with Maxwell's ideas. Having observed that Maxwell, in his treatise, described the system (71*b*) of the last section, with no allowance for self-induction, and knowing this system to be quite inapplicable to short lines, I (in ignorance of Kirchhoff's investigation) made the necessary change of bringing in the electric force of inertia (*Phil. Mag.*, August, 1876), converting the system (71*b*) to the following:—

$$\left.\begin{aligned} -\frac{d\mathrm{V}}{dx} &= \mathrm{RC} + \mathrm{L}\frac{d\mathrm{C}}{dt}, \quad q = \mathrm{SV}, \\ -\frac{d\mathrm{C}}{dx} &= \frac{dq}{dt} = \mathrm{S}\frac{d\mathrm{V}}{dt}, \end{aligned}\right\} \quad \frac{d^2\mathrm{V}}{dx^2} = \mathrm{RS}\frac{d\mathrm{V}}{dt} + \mathrm{LS}\frac{d^2\mathrm{V}}{dt^2}, \quad (72b).$$

The equations on the left side show the elementary relations, and that on the right the resultant equation of V.

The difference from (71*b*) is only in the first equation of electric force, and in the characteristic equation of V. To the electric force due to V is added the electric force of inertia $-\mathrm{L}\dot{\mathrm{C}}$, where L is the inductance of the circuit per unit length, according to Maxwell's system of coefficients of electromagnetic induction. That is, L consists of three parts, say $\mathrm{L_0}$ for the dielectric, $\mathrm{L_1}$ for the wire, and $\mathrm{L_2}$ for the return. Their expressions will vary according to the size and shape of the conductors and their distance apart. In case of symmetry about an axis, their determination is very easy by the square of force method. The magnetic energy per unit length is $\frac{1}{2}\mathrm{LC}^2$. It is also $\Sigma\mu\mathrm{H}^2/8\pi$, if H is the magnetic force, and the summation extends over the region of space belonging to the unit length. As H is a simple function of C and of the distance from the axis, the integration is very easily effected.

L is calculated on the hypothesis that the current density has always the steady-flow distribution, just as R is the steady-flow resistance. As it is, strictly speaking, impossible to have the Faraday law of induction true in all parts of the conductors without some departure from the steady flow distributions, it is satisfactory to know that more exhaustive investigation shows that L, not $\mathrm{L_0}$, should be used in a first approximation.

In connection with this matter I may mention that rather singularly, just as I was investigating it, my brother, Mr. A. W. Heaviside, called my attention to certain effects observed on telegraph lines, which could be explained by the combined action of electrostatic and electromagnetic induction, causing electrical oscillations which made the pointers of the old alphabetical indicators jump several steps instead of one. When freed from practical complications, and worked down to the simplest form, the matter reduced to this, that the discharge of a condenser through a coil is of an oscillatory character, under certain circumstances, and I described the theory in the paper I have mentioned. It had been given by Sir W. Thomson in 1853, but it is a singular circumstance that this very remarkable and instructive phenomenon should not be so much as mentioned in the whole of Maxwell's treatise (first edition), though it is scarcely possible that he was unacquainted with it; if for no other reason, because it is so *simple* a deduction from his equations. I lay stress on the word simple, because it is not to be supposed that Maxwell was fully acquainted with the whole of the consequences of his important scheme.

Mr. Webb, the author of a suggestive little book on "Electrical Accumulation and Conduction," had very early practical experience of electrical oscillations in submarine cables, when they were coiled up on board ship, ceasing, more or less, as they were submerged.

It is far more difficult to obtain a satisfying mental representation of the electric force of inertia $-\mathrm{L}\dot{\mathrm{C}}$ than of that due to the potential, or $-d\mathrm{V}/dx$, as described in the last section. The water pipe analogy is, however, simple enough. Let L be the mass of the fluid per unit length, C its velocity, then $\frac{1}{2}\mathrm{LC}^2$ is its kinetic energy, LC its momentum, $\mathrm{L}\dot{\mathrm{C}}$ the force that must be applied to increase it, $-\mathrm{L}\dot{\mathrm{C}}$ the force of reaction. A mental representation of many of the phenomena connected with electrical oscillations is also very simply got by the use of the fluid analogy. It is, however, certainly wrong, as we find by carrying it out more fully into detail. Remark, however, that, as $\frac{1}{2}\mathrm{LC}^2$ is the magnetic energy per unit length, LC is the *generalised* momentum corresponding to C as a generalised velocity, $\mathrm{L}\dot{\mathrm{C}}$ the generalised externally applied force, an elec-

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tric force, of course, and $-\mathrm{L}\dot{\mathrm{C}}$ the force of reaction—that is, the electric force of inertia. This is by the simple principles of dynamics, disconnected from any hypothesis as to the mechanism concerned.

The magnetic energy must be definitely localised in space, to the amount $\frac{1}{2}\mu\mathrm{H}^2/4\pi$ per unit volume, and be regarded as the kinetic energy of some kind of motion in the magnetic field. When steady, there is no force of inertia. But when H changes, and with it C, since these are rigidly connected (in our first approximation) there is necessarily a force of inertia, which, reckoned as an electric force appropriate to C as a generalised velocity, is $-\mathrm{L}\dot{\mathrm{C}}$ per unit length.

In the discharge of a condenser through a coil, if we start with a charge, but no current, there is in the first place only the potential energy of the displacement in the condenser. The discharge cannot take place without setting up a magnetic field, proportional in intensity to the current at any moment, so that the original electrical energy is employed in heating the wire, and also in setting up the magnetic energy. When the condenser is wholly discharged, the inertia of the magnetic field keeps the current going, and it will continue until the whole energy of the magnetic field is restored to the condenser (less the part wasted in the wire) in the form of the energy of the negative displacement there produced. Except that the charge is smaller, and of the opposite sign, everything is now as when we started, so that we may begin again and have a reverse current, continuing until the condenser is again charged in the same sense as at first, with no magnetic field. This is the course of a complete oscillation. But if the resistance be of or above a certain amount, depending on the capacity of the condenser and the inductance of the coil, the oscillations cease, and the discharge is completed in a single current which does not reverse itself.

Similar effects take place, in general, in any circuit, when a change is made which involves a redistribution of electric displacement, or its total discharge, but the full theory is usually very difficult to follow in detail. The so-called "false discharge" of a submarine cable is, however, easily comprehensible by the last paragraph.

If, in the characteristic equation of V in (72*b*), we take $\mathrm{L}=0$, reducing it to that of (71*b*), we have simple diffusion of the static charge. If, for instance, the ends of the line be insulated, any initial state of charge will settle down to be a uniform distribution, in a non-oscillatory manner, the smaller inequalities (smaller as regards length of line over which they extend) being wiped out rapidly, the larger more slowly; the law being that similar distributions subside similarly, but in times which are proportional to the squares of the lengths concerned.

If, on the other hand, we take $\mathrm{R}=0$ in the characteristic equation of V in (72*b*), we have an entirely different order of events. As there is no waste in the wire, it is clear that the total energy of any initial state, electric and magnetic, remains undiminished. We can definitely divide the initial state into two distinct states travelling in the manner of waves in opposite directions, and being continuously reflected at the ends. Or, more simply, set up a charge at a single point of the line. It will divide into two, which will go on travelling backwards and forwards for ever. But into details of this kind we must not be tempted to enter at present, the immediate object being to lay the foundations for a more general theory.

When both terms on the right side of the characteristic equation are counted, propagation takes place by a mixture of diffusion and wave transfer. A wave sent from one end of the line which would, were there no resistance, travel unchanged in form, and be reflected over and over again at the ends, in reality spreads out or diffuses itself, as well as, to a certain extent, being carried forward as a wave. The length of the line is an important factor. Wave characteristics get rapidly wiped out in the transmission of signals on a very long submarine cable, so that the manner of variation of the current at the distant end approximates to what it would be in the case of mere diffusion.

On the other hand, coming to a very short line, there are, every time a signal is made, immensely rapid dielectric oscillations, before the steady state is reached, due to to and fro reflection. As a general rule, this oscillatory phenomenon is unobservable, but it is none the less existent. It is customary to ignore it altogether in formulation, regarding the matter as one in which electromagnetic induction alone is concerned. Of course the magnetic energy is then far more important than the electric, and the current in the wire rises nearly in accordance with the electromagnetic theory.

The immense rapidity of the dielectric vibrations is one reason why they are unobservable, except indirectly, and under peculiar circumstances. Sometimes, however, they become prominent, especially when a circuit is suddenly interrupted, when we shall have large differences of potential. Mr. Edison discovered a new force. The enthusiasm displayed by his followers in investigating its properties was most edifying, and thoroughly characteristic of a vigorous and youthful nation. But it was only the dielectric oscillations, it is to be presumed; unless indeed it be really true, as has been reported, that the renowned inventor has kept the new force concealed on his person ever since.

How is it, it may be asked, that in the rise of the current in a short wire, according to the simple electromagnetic theory, the potential at any point in the wire is regarded as a constant, viz., its final value when the current has reached the steady state? Thus, as we have

$$\frac{e}{l}-\frac{d\mathrm{V}}{dx}=\mathrm{RC}+\mathrm{L}\frac{d\mathrm{C}}{dt}, \text{ and } \frac{d^2\mathrm{V}}{dx^2}=0,$$

if e is the total impressed force in the circuit, and l the length, the potential variation $d\mathrm{V}/dx$ must be constant. Supposing then e to exist only at $x=0$, the current will rise thus,

$$\mathrm{C}=\frac{e}{\mathrm{R}l}(1-\epsilon^{-\mathrm{R}t/\mathrm{L}}),$$

and the value of $-d\mathrm{V}/dx$ must be e/l, from the very moment e is started, and so long as it is kept on.

When we seek the interpretation, in the more general theory, we find that although the current oscillations become so insignificant on shortening the line that the well-known last formula becomes valid, practically, yet the potential oscillations remain in full force during the variable period. A wave of potential travels to and fro at the velocity $(\mathrm{LS})^{-\frac{1}{2}}$, making the potential at any one spot rapidly vibrate between a higher and a lower limit, though not according to the S. H. law, but in such a manner that its mean value is the final value, whilst the limits between which the vibration occurs continuously approach one another; the vibration, on the whole, subsiding according to the exponential law, with $2\mathrm{L}/\mathrm{R}$ as time constant. The quantity e/l, which in the above rudimentary theory is taken to be the actual potential variation, is really the mean value of the real rapidly vibrating potential variation, at every point of the circuit and during the whole variable period, at whose termination, on subsidence of the vibrations, it becomes the real potential variation.

To get rid of this vibration, we have merely to distribute the impressed force so as to do away with the potential variation.

Having now got the elementary relations established, we can proceed to the simplest manner of extending them to include the phenomena attending the propagation of current into the conductors from the dielectric.

(To be continued.)

Electric Light for Microscopic Projections.—Prof. Stricker in lecturing at Berlin before the Society of Natural History and of Medicine has employed with much success an arc lamp of 4,000 candle-power for the projection of microscopic sections upon a screen, employing a magnifying power of six to eight thousand diameters. Of course the success of an experiment of this character depends almost entirely upon the optical qualities of the apparatus, but in this instance it is stated that the definition obtained was so satisfactory that "important results in the progress of the study of anatomy" are anticipated from the further use of the electric light in this connection.

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CONTENTS.

Notes ... 1
Elementary Electricity and Magnetism.—II. Illustrated ... 6
Testing Dynamo Machines. By J. Swinburne ... 8
Electromagnetic Induction and its Propagation. By Oliver Heaviside. (Continued.) ... 10
OURSELVES ... 12
Insurance and Electric Lighting ... 13
Correspondence. Illus. ...14 and 15
Literature ... 15
M. Marcel Deprez on the Magnetic Circuit ... 15
On Conductivity of very Dilute Solutions. By Dr. F. Kohlrausch ... 16
On Continuity of Electric Conduction. By Dr. Hopkinson ... 17
On the Electric Resistance of Magnetite. By Prof. S. P. Thompson ... 18
Electric "Conduit" Tram Lines. Illustrated ... 18
Duplex Telephone Circuits. Il'us ... 18
The Society of Telegraph-Engineers and Electricians ... 20
The Pre-Determination of the Characteristics of Dynamos. By G. Kapp ... 20
Legal Intelligence ... 22
Incandescent Lamp Manufacture ... 24
West India and Panama Telegraph Company ... 24
Companies' Share List ... 24
Telegraph Traffic Receipts for October ... 24

OURSELVES.

The first number of a new volume is a fitting and convenient place for any observations of a familar and personal kind which conductors of journals may at times desire to address to their readers; and in beginning to-day the eighteenth volume of *The Electrician* we avail ourselves of the privilege to offer a few remarks relating to the past career of our journal, together with some friendly suggestions as to its future prospects. As regards the past, we have much reason to be grateful to our helpers and supporters. Expressions of gratitude, however, would not count for much if we failed to show that we have deserved the help and support received; but seeing that these proofs of goodwill continue to be bestowed upon us, we may reasonably claim to have been not undeserving of them. When we say we, we mean, of course, *The Electrician*. Dr. Johnson tells us that when we run down self we do not mean our own selves in a literal sense; perhaps we may be permitted to observe on this that when a journal praises itself it only means it in a journalistic sense. As a journal *The Electrician* is able to look back with some pride on the work it has achieved for electrical science and electrical industry; and this largely by steady perseverance in a consistent course, which events are proving to be the right one; by sacrificing immediate popularity for an enduring reputation; and by subordinating pecuniary gain to the permanent interests it has undertaken to promote.

Turning to the practical details of our work, we have done all that the measure of our resources permitted to obtain the best authentic information of all scientific and industrial progress in the field of electrical enterprise. As our resources increased the quality of our matter and the finish of our illustrations have gone on improving. We confidently assert that in neither of these respects have we ever fallen below our contemporaries; and for a long time past they have frequently acknowledged our superiority—though not our identity—by reprinting our original matter as their own, which is, we suppose, the sincerest form of flattery journalism is capable of. Like all other newspapers we have to pay this kind of compliment at times, and we do it ungrudgingly; but, as a whole, our pages are occupied with original papers, no scientific journal with which we are acquainted having so largely invited and obtained the contributions of leading or rising members of the profession for its pages. The policy with regard to electric lighting constantly advocated in this journal, like its policy in relation to submarine cable laying, has sometimes been called in question; but in respect to the former, our aim has been to deprecate precipitate adventures, and in respect to the latter to protect existing interests against adventurers. Where genuine and legitimate work was to be done, we have helped it to the best of our power; where it was plainly speculative, or promoted merely out of rivalry, we have opposed it with all our might. The owners of submarine cables may or may not have cause to be grateful, but they have certainly no ground to deny the vigour and zeal with which their interests have been defended in the pages of this journal. The interests of electric lighting have been not less strenuously upheld by us; but, for reasons which need not now be recalled, it has sometimes been impossible to support the projects of particular undertakers in the interest of electric lighting as a whole. Naturally they are in a hurry to make money. For our part we are only anxious that the electric light should succeed, leaving the money-making to those it may concern later on. These remarks apply in like manner to the Telephone Companies, and the line we have pursued in regard to them.

As to the future, we have every reason to be sanguine that our list of contributors will go on enlarging and our number of subscribers increasing. But a journal of this kind has several difficulties to contend against, some of which are unavoidable, others which are easily remedied. The unavoidable are the multiplication of journals of all kinds, including those of a technical, industrial, and scientific kind. We do not fear their competition, but we do feel some apprehension lest the interests of the various industries related to electrical research may suffer from the diffusion and dilution of useful information to an extent which will practically prevent its reaching the eye and understanding of those for whom it is intended. If this should happen, it will be the fault of good natured scientists who out of personal regard or mere thoughtlessness generously

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respond to any invitation to supply articles without due regard to the fitness of the place in which they will appear. No medical man ever dreams of writing on a medical question to any but the organ which represents his profession. Why physicists, chemists, and electricians should depart from this useful rule is more than we can explain. But they do, and one result is that if a reader interested in physical, chemical, or electrical subjects desires to keep himself fully informed, he must purchase, not one, but several expensive journals, any one or two of which ought to fully suffice. There may be room enough for the growth of new journals; but none of them would be the worse for minding its own peculiar business; and students would certainly be spared a great tax on their pockets and time if they knew where to go to seek what they want, and were certain to find it there.

Only on one other point do we wish to offer a word of remonstrance. We are often reproached with having neglected to notice this or that matter of interest in due time; and, on the other hand, it is hinted that where we do admit a notice we are advertising some favoured client. The actual fact is that, not being omniscient, we must to a large extent depend on notices personally furnished. To put it plainly, we favour those who favour us. People who forget that we are established to represent their interests and to make public their work must not be surprised if we occasionally forget them. What we want in this relation is information; if it is not furnished us, or means of obtaining it put in our way, obviously we cannot publish it. This is all the favour we have shown in the past, and all we ever mean to show in the future volumes of *The Electrician.*

INSURANCE AND ELECTRIC LIGHTING.

"The truth and nothing but the truth" is difficult to obtain, and in these days, when so many people fight for their own hand at all hazards, plain, straightforward honesty is at a discount. We are going to endeavour to give some unvarnished facts in connection with the subject mentioned at the head of this article. In the first place, recent criticism endeavours to fasten on to the insurance companies the odium of framing rules that tend to retard the progress of electric lighting. Now this is about as wide of the truth as any statement can possibly be. We prefer to think these critics are ignorant of the true state of the case rather than to imagine the statements deliberately made. Is it a fact that the insurance companies add nothing to their premiums on account of illuminants, except in certain particular cases where the risks are specially hazardous? If this is so—and we have reason to suspect the statement to be correct—then progress is not retarded by increase of premiums. But the critics say the premiums should be reduced when electric lighting is in question, for they hold strongly "it is so much less dangerous than gas." Facts are strange creatures, and facts tell us that outside of the work performed in accordance with insurance rules, the percentage of fires through electric lighting apparatus is larger than through gas apparatus. The reason of this will be seen below. Thus insurance companies, which have no reason for preferring gas to electric illuminants, object to the latter except under conditions of distribution laid down by them. We fail to see how progress is delayed by such action. Further, the insurance companies are said to be antagonistic to electric lighting, because they refuse risks where the work has not been carried out under their rules. We commend the companies for doing so, and our readers will do the same if they are honest in their endeavours to develop the industry in a proper manner.

We have been at some trouble to get at the facts; for the present we will content ourselves with mentioning one incident which occurred a few weeks ago. A letter was drafted by the officers of one of our largest companies, which it was intended to send to *The Times.* The draft letter was submitted to several other well known firms and companies. Without exception, we believe, all the experienced men to whom the letter was submitted agreed as to the truths stated therein; but on careful discussion it was deemed inexpedient to send the letter to *The Times,* or any other of the daily papers, simply because the publication of the letter would probably have led to such a scare amongst the non-technical public that the opposite effect to that intended would have happened, and the industry would have suffered. The text of the letter may be said to have been "bad workmanship." We have reason to know that previous to the letter being drafted, and during the discussion upon it, a number of examples of atrociously bad workmanship was before those who agreed with the terms of the letter. We have seen some of the specimens, and we have other and perhaps worse specimens that have not been shown to any person outside our own office. Coming back to the rules laid down by the insurance companies, it may be asked what is the plain duty of the companies in this matter? Are they not intended to protect the shareholders of the insurance companies from loss? Outside the question of loss, is it not the interest of the public to decrease the probability of fires, and to stop the possibility of putting in such materials and workmanship as will, in the opinion of any man but a born bigot, lead sooner or later to the total or partial destruction of the edifice? The Phœnix rules, for example, which apply to this country, were adopted after full discussion with, and in accordance with the opinions of, the best authorities engaged in the practical work of Electric Lighting. So far as we can gather, there has never been the slightest hesitation by the best known firms and companies in complying with the rules as laid down by the insurance companies. They are glad to follow the rules. Indeed, some practical men hold that the rules are not stringent enough. The men who criticise such rules adversely are generally men without experience, and usually are ashamed to make an attack in public, doing so under a *nom de plume,* so that no one can tell the value of the criticism. Another class of critics come from those who intend to make money, make it honestly if possible, but, at any rate, to make money. It is these men who take contracts at prices which cannot allow of good workmanship or good materials, and it is from such work that danger arises. Such men are the curse of the electrical as they are the curse of all industry. It is their action which retards the development of the industry, and upon them must fall the blame.

Those readers who are unable to credit our statements may ask, among others, such firms as Crompton and Co., Wilson Hartnell, Messrs. Verity and Sons, Messrs. Laing, Wharton, and Down, &c., and such companies as the Brush, Edison-Swan, Siemens Brothers, Woodhouse and Rawson, &c., their opinions concerning the action of the insurance companies in regard to bad workmanship. On the insurance side of the question Mr. Heaphy, who has had a good deal of experience in this matter, will be able to give his opinion. We invite such as are endeavouring to do good work to come forward, and once for all put upon record their conclusions upon this subject.

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CORRESPONDENCE.

A NEW ACCUMULATOR CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 22nd October, page 484, you mention that a new accumulator cell has been brought out by M. P. Gudot, the principal feature of which appears to be in the "shape of the holes in which the active material is placed." You then describe them as having the "shape of truncated cones or pyramids, the plates being made up in pairs, with the widest sides of the holes in juxtaposition."

Might I call your attention to a patent specification (A.D. 1885, 14th July, No. 8540), in which an inventor claims a "voltaic battery having for negative elements plates of lead perforated with tapering holes, filled with oxide of lead and fixed together in pairs?"—Yours, &c.,

WM. C. FISHER.

17, Cornhill, E.C., November 4th, 1886.

THE JARMAN ELECTRICAL TRAMCAR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think a few corrections are necessary in your note upon my model electric tramcar, published in *The Electrician* of October 29th.

1st. The model is 4ft. 7in. long, and not 2ft. as you state.

2nd. I do claim a special feature in the construction of the electro-motor, by affixing two armatures upon a shaft or spindle for the purposes claimed, *no* clutch being employed.

3rd. Spur gearing is used but *no* mitre wheels. This latter plan is a sad mistake, as many will have cause to know in all probability. The gearing designed for the model answers perfectly. I am quite acquainted with the effect of passing a heavy current through an electro-motor for the above purpose, having had sufficient experience in this direction to lead me to the present design. When a copper conductor can be made to carry a current five or six times more than it will safely bear, *then* armatures will be made that will not heat. I have taken this excessive heating of the electro-motor as it stands, and as far as tests have gone they bear out exactly what was designed. As far as the teeth of the gearing are concerned, there is another material I intend to employ which is superior to hornbeam.

There is another important feature in my present design for electrically propelled cars which has been entirely overlooked, a feature that every electrically propelled car *must* possess before it will be permitted for general use. I hope to point this out when the full size car is completed.—Yours, &c.,

82, Kellett-road, Brixton, Nov. 6th, 1886. A. J. JARMAN.

[If Mr. Jarman will refer again to the note in which we mentioned his tramcar, he will perceive that our reference to the heating of the armatures of series-wound motors on starting the current was mentioned as a point—in fact, the *chief* point—to be considered in favour of his system.—ED. *E.*].

THE LAW OF THE SQUARES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Since the time of Coulomb, all the manuals have glibly repeated the law that electric and magnetic forces decrease as the square of the distance, and I now have before me a paper read before the British Association, with a discussion thereon, upon the celebrated Cavendish proof of that law. For the life of me I cannot obtain from all the display the ghost of an idea of its validity. If Lord Rayleigh, or some of his eminent and esteemed compeers, would condescend to translate this high shibboleth into a brief paraphrase, reduced to the level of a common understanding, it might be appreciated by a very wide audience. If it only means that these forces decrease as the law of the squares, *under radiant conditions*, it goes for very little, because under ordinary circumstances such conditions seldom or never subsist.

Given a uniform field of force, as between the plates of a condenser, and *we know* that these forces decrease *directly* as the distance apart; a double thickness of dielectric gives a double resistance, or half the inductive effect, and for round surfaces, as in the case of insulated wires, *we know* that the law of decrease is well established by the logarithm of the ratio between the inner and outer circumference of the dielectric.

But this does not approximate the law of the squares, as in departing from flat surfaces it varies in an opposite direction.

It is not an easy matter to obtain a strictly uniform field of magnetic lines of force; but in proportion as that is attained must the same law of decrease with distance prevail, as between the plates of a condenser.

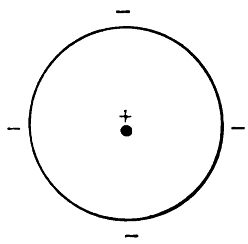
Let us now test a straight bar magnet, and the lines of force may vary in many ways according to the character and shape of the body presented and to the relative nature of the medium involved; but in a wide sense we may say that for a very limited space beyond the pole the force decreases *directly* as the distance, and rapidly varies until we pass a region where the law of the squares must be approximated, beyond which the rate increases far beyond that ratio, until from the curvature of the lines to the opposite pole we get approximately no force at all.

Is it, then, right to say of this force, as a whole, that it decreases as the square of the distance?

May we not go farther in this direction, and say that there is nothing in the nature of light or sound vibrations *per se*, which determines their decrease as the law of the squares? The feeble sounds heard through a stethescope do not so decrease, nor do the rays of light transmitted through a telescope; but in both light and sound there is no duality of force to modify or prevent the usual conditions of true radiation.

In the Cavendish experiment I presume we have a small charged sphere, in the centre of a bare room, with lines of force radiating to the walls, floor, and ceiling, where the opposite charge necessarily subsists. This is probably a sufficient approximation for the purpose in view; but for absolutely true radiation, methinks that the opposite charge should be on a circular circumference, equally distant at all points from the central force.

In like manner the Coulomb experiment is very much of the same character, which may perhaps be better understood by a rough diagrammatic representation. In this case we may



imagine a small metallised pith-ball, charged at the centre, and the opposite charge necessarily resident upon the surrounding surface of the electrometer. If we now imagine another similar ball, near the outside, it would be inductively affected, and would be attracted to the centre with a force *increasing* as the square of the distance up to actual contact. We may now vary this according to the actual conditions of the Coulomb experiments, and whether we charge the two balls similarly for repulsion or oppositely for attraction, the general effects will be substantially similar. The balls are small spheres, and the forces are virtually resident at their centres, and in any case the conditions are roughly approximative of radiation. It is common to speak of the forces as resident in the two balls, but the effect is really due to an action of the lines of force in the dielectric air.

We may now go back to the Cavendish room, and vary the experiment in two ways: 1st. With the charged sphere, near to one of the walls of the room; and 2nd, with a lighted candle in its place. In the latter case the radiation would be perfect, and decrease according to the law

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of the squares would be as truly evinced towards the nearest corner as to one the most distant. But not so with the sphere; its force would be chiefly accumulated towards the nearest surface, where it would approximate the law of flat surfaces, and the distant parts would be correspondingly denuded of the influence.

Let it be understood that these thoughts are offered in an inquiring spirit rather than in a dogmatic sense.—Yours, &c.,

SAM. E. PHILLIPS, F.C.S.

LITERATURE.

Short Lectures to Electrical Artizans. By J. A. FLEMING, M.A., D.Sc. [London: E. and F. N. Spon.]

This book is a transcript of a course of experimental lectures delivered to a practical audience. We think the author is quite justified in seeking, by publication, a larger audience for these lectures than that which originally listened to them in the works of Messrs. Crompton and Co. It was an admirable step on the part of Mr. Crompton to arrange for the delivery of these lectures to the pupils and workmen connected with his firm; but the arrangement could not have been an easy one for the lecturer, who must have felt that he would have much preferred an audience of a more homogeneous character. Unfortunately, in spite of all the mechanics' institutes and similar places established for the benefit of working men, it must be confessed that the average English craftsman is not sufficiently alive to the benefit which must result from technical and scientific studies bearing on the branch of the manufacturing industry in which he may be engaged. Mr. Crompton was no doubt aware of this when he requested Dr. Fleming to deliver his lectures, and he probably took the best means in his power to benefit his men by placing before them information of which, if they are like the majority of working men, they would not of their own accord have gone in search. We feel that there may be many amongst our readers, in these days of the apotheosis of the British workman, who will object to our remarks that they are unjust. We wish we could believe this to be the case. We know it is not, and that in many so-called "Mechanics' Institutes" there is hardly a mechanic on the roll of members. It is a fact to be regretted, but it is one which nobody who has worked much in connection with such institutions will deny, that the efforts which have so long been made to reach working men succeed only in a very partial degree. They reach, not the actual mechanics and craftsmen, but a class a step or two higher in the social scale. The author has done his best under the circumstances.

The lectures, as might have been expected, are a little above the average workman, and are just enough to refresh the memories of the pupils who, we presume, were learning to apply practically the scientific knowledge which they had gained at technical schools and colleges. This is not faint praise. The book is an excellent one in its way, and as "introductory to larger treatises," as the author puts it in his preface, is all that can be desired. That one part of his audience were, or should have been, already acquainted with the larger treatises, and that the other part were probably for the most part ignorant of even the elements of scientific knowledge of their work was the misfortune and not the fault of the lecturer.

But we think this book fills a distinct void in electrical literature. It is a great relief to read it after having, by a hard fate, been obliged to examine numerous well-meant but imperfect attempts to impart knowledge of modern electrical development in the form which is known, by an abuse of terms, as "popular" scientific literature; for the book, although a little unequal, is clear, exact, and to the point, and is characterised by an evident—and successful—desire to enable distinct and unclouded conceptions to be formed of the various laws and phenomena dealt with. It is in very good taste, too, that there is no prominence given to the manufacture or methods of any one firm or constructor.

The information is brought up to date—a thing hitherto undreamt of by any "popular" writer. For instance, Dr. Hopkinson's method of testing the efficiency of a dynamo and motor is fully given; and Mr. Shelford Bidwell's recent investigations on the magnetisation of iron are fully described in an appendix. We are glad to notice (page 122, Fig. 50) a description of the excellent apparatus for showing the analogy between fall of pressure in hydraulics and fall of potential in electricity. We do not remember to have seen this simple apparatus described in any text book on electricity. It is a simple though a most instructive one; but we would suggest that the author should place in the horizontal pipe a piece of rubber tube capable of constriction, for the purpose of demonstrating the difference of potential produced by the insertion of "a resistance" in a circuit. We notice several old friends amongst the engravings, but they are all welcome ones, notably the plate from M. Kapp's book, showing the various forms of field-magnet of dynamos and the views of lines of force from the same source.

Perhaps too much space is given to measuring instruments, for although science may be measurement, measuring instruments are perhaps not the direction in which the most satisfactory progress has been made in electric light matters. We trust that in a future edition Dr. Fleming will add considerably to his index. In conclusion, we unhesitatingly recommend this little work to those amongst our readers who wish to place in the hands of their friends an introduction to the science of practical electrical engineering.

M. MARCEL DEPREZ ON THE MAGNETIC CIRCUIT.

On the 26th October a paper was presented to the *Academie des Sciences*, by M. Marcel Deprez, upon the intensity of the magnetic field in dynamo machines, of which the following is an abstract. We may remark in advance that M. Deprez's views are not in accord with the theory which has just received so remarkable a vindication at the hands of Mr. Kapp in the paper which was read last night at the Society of Telegraph-Engineers, "On the Predetermination of the Characteristics of a Dynamo." We should like to ask M. Deprez whether the views which he puts forward enable him also to determine beforehand the performance of a machine built to a given specification. If the theory will stand this test the position will become one of decided interest.

M. Deprez commences by stating that he has undertaken a long series of experiments in order to determine the influence of the shape and dimensions of the air space upon the intensity of the magnetic field. The intensity of the field was inferred from the measurement of the force exerted upon a movable conductor traversed by a continuous current. The first conclusion arrived at was that "contrary to what certain electricians have affirmed, *the intensity of the field decreases much less rapidly than the distance between the poles increases.*" For instance with two horse-shoe electro-magnets having cores 200mm. in diameter, the intensity of the field was reduced only one half, when the distance between the poles was increased from 7·5mm. to 75mm.—that is ten-fold.

"When the field is comprised between a magnetic pole and an iron armature, magnetised by its influence, the decrease of the intensity, corresponding to the increase of the distance, is more rapid; but it is still very far from what was once supposed, since, instead of being proportional to the square of the distance of the magnetic pieces in question, as it has been affirmed by certain persons led by a crude analogy, it is superior even to the inverse of the square root of the distance. To render this more clear, when the distance increases from 1 to 4 the intensity of the field falls from 1 to 0·6.

"In all cases the larger the cores of the electro-magnets, the more considerable is the current which excites them; the thicker the armatures upon which they act, the less is the influence of the distance from the armature to the poles of the electro-magnet. *Hence it follows that on bringing the armatures of the inducing poles very close, we increase the intensity of*

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the field very little, whilst we reduce the place available for the induced wire almost to zero.

"If in a dynamo machine we vary the annular space compri ed between the polar expansions and the outer surface of the iron core of the ring as well as the quantity of induced wire coiled upon the latter, so as to fill the annular space as completely as possible without interfering with the free action of the machine, it is certain that the efficacy of the machine will vary with the dimension of the annular space; it will be null when this dimension is very small, because the insulating materials which surround the iron ring, as well as the clearance which must exist between it and the fixed polar pieces, will absorb all the available space, and leave no place where the induced wire may be introduced. It will be, if not null, at least very feeble, if we give an excessive dimension to the annular space. There exists, therefore, a dimension of this annular space corresponding to the greatest possible efficiency of the machine. But before searching for the most favourable dimension we must define this efficiency. If we determine all the dimensions of the machine (except the annular space) its speed of rotation and the electromotive force which it should produce, I will say that its efficiency is greatest when the internal resistance of the ring is at a minimum.

"If we call x the dimension of the annular space taken in the direction of the radius of the ring; a, the minimum value of the space allowed for the insulating matters which cover the iron core, for the clearance indispensable to the free working of the parts, and, in a word, for all matter *other than the copper* conductor of the current coiled around the induced ring, such space being likewise taken in the direction of the radius, and H the intensity of the field, it can easily be shown that the internal resistance of the machine is a minimum when the function $H^2(x-a)$ is a maximum.

"The experiments referred to above show that this maximum occurs for values of x much greater than is commonly supposed. These results, moreover, merely confirm those which I obtained about eighteen months ago with Gramme machines, in which I diminished the annular space more and more. The intensity of the magnetic field increased beyond doubt, but the machine became very decidedly worse as the annular space became smaller.

"In machines of high tension, such as those which I had constructed for the experiments at Creil, the value of the constant a is much greater than in machines of a low tension, because they require a far more perfect insulation.

"Hence it results that the function $H^2(x-a)$ reaches its maximum only for values of x very much greater than if a were small. This is the reason why I have been obliged to give the annular space so great a value in the Creil machines. This will readily appear if we know that the distance from the outer part of the induced wire to the polar pieces reaches in places 0·01 metre, and that the thickness of the insulating layer interposed between the iron core and the first layer of the induced wire was 0 0075 metre. This then made a space of 0 0175 metre entirely lost for the useful effect of the machine, so that if I had only given to the annular interval 0 020 metre, there would remain for the induced wire merely 0·0025 metre, that is to say, room enough to lodge a single layer of wire, the machine would not have yielded the eighth part of the electromotive force required.

"I have made a few experiments upon the influence of the dimensions perpendicular to the lines of force, and I have been able to ascertain that unless the polar pieces are very thick in the direction of the lines of force the intensity of the field is approximately in the inverse ratio of the developed surface of the polar expansions taken perpendicularly to the lines of force.

"With electro-magnets, the core of which was 200 millimetres in diameter, the magnetic field comprised between the poles has reached the value of 15,400 C.G.S. units, when the polar pieces of a square form measured 200 millimetres per side and were 3 millimetres apart; it was still 11,400 units when the distance was 20 millimetres. The electric work expended collectively in the helices of the two electro-magnets amounted to 9 horse-power."

BRITISH ASSOCIATION, 1886.

One of the most important innovations introduced at the meetings of the British Association in 1885 led to the admirable paper of Prof. Lodge on "Electrolysis." This paper was supplemented at the 1886 meeting, recently held, by a series of short papers on special points in electrolytic theory, which we commence to give herewith:—

ON CONDUCTIVITY OF VERY DILUTE SOLUTIONS.*

BY DR. F. KOHLRAUSCH.

This memoir is an extension of previous work, and was undertaken for the purpose of verifying the following laws laid down by Kohlrausch in a former paper:—

1. If dilute solutions of various salts be prepared, having their strengths proportional to the chemical equivalents of the salts, then the specific conductivities of these solutions are of the same order of magnitude.

2. In dilute solutions, under a given electromotive force, each of the ions moves through the liquid with a fixed velocity dependent on its own chemical nature, and independent of that of the other ion. This is termed the "law of independent migration."

3. The influence of change in temperature upon the conductivity tends, as dilution increases, to a limiting value, the temperature coefficient being the same, within narrow limits, for all neutral salts.

In his previous investigations Kohlrausch had determined the specific conductivities of solutions of varying strength, from saturation down to a few per cents, and from observations thus obtained had deduced the conductivity in more dilute solutions by extrapolation. In the present memoir he verifies and corrects the results thus obtained by the employment of solutions whose strengths vary from 1·0 to 0·00001 gramme-equivalents per litre. (The strength thus estimated is termed the "molecular content.")

In measuring the resistances a Wheatstone bridge is used, with alternating currents and a telephone as indicator (the paper deals at some length with the advantages and difficulties of this method); the specific conductivities are expressed in terms of that of mercury, and calculated for a uniform temperature of 18° C.

In working up the results the conception of "specific molecular conductivity" is employed, this being defined as the ratio k/m of the specific conductivity k of the solution to the molecular content m. As the specific molecular conductivities are all very small, Kohlrausch tabulates the values of $10^8 . k/m$, instead of k/m simply. The values of this ratio are exhibited graphically, by plotting in a curve, with $m^{\frac{1}{3}}$ as abscissa, this quantity being chosen because it expresses "the reciprocal of the mean [distance," or, in other words, the *mean relative proximity* of the molecules—*i.e.*, the magnitude on which the specific molecular conductivity is most directly dependent.

The material thus obtained is amply sufficient to verify the three statements above mentioned, the very important law of independent migration in particular receiving a full confirmation. In addition a large number of interesting relations disclosed themselves, which may be summarised as follows:—

1. If the solution be sufficiently dilute the specific molecular conductivity k/m is, for all neutral salts, independent of the strength of the solution, or each molecule conducts the current independently of every other. In other words, the specific molecular conductor has a limiting value. These limiting values are not the same for all salts, or even for those of the same base or acid; their magnitude depends on the nature of both ions.

2. The velocity with which the ions move past each other in extremely dilute solution, under an electromotive force of 1 volt per linear millimetre, is determined in millimetres per second by multiplying the specific molecular conductivity of the electrolyte by 11000† (or Kohlrausch's tabulated numbers

* Abstract of F. Kohlrausch's Paper "*Ueber das Leitungsvermögen einiger Electrolyte in äusserst verdünnter wässeriger Lösung*" (*Wied. Ann.* XXXVI. p. 161).—Drawn up by E. F. J. Love, and communicated to the British Association at Birmingham.

† [This appears to be necessary in order to reduce measures in terms of mercury to absolute measure.—E. F. J. L.]

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by 0·00011). The numbers thus obtained for the various salts examined all lie between 0·14 and 0·10 *mm/sec.*

3. The specific molecular conductivity of a salt in dilute solution being proportional to the sum of the velocities of the separated ions, the values of these absolute velocities may, as Kohlrausch had shown previously, be determined from the experiments in the following way:—

Let u_1 and v_1 be the absolute velocities of K and Cl, u_2 and v_2 those of Na and Br; then the

Specific molecular conductivity, k/m, of $KCl = (u_1 + v_1)/11000$
" " " " $NaCl = (u_2 + v_1)/11000$

and so on; hence the conductivities of KCl, NaCl, KBr, and NaBr, contain all that is necessary for determining the absolute velocities of K, Na, Cl, and Br; since by the law of independent migration the velocity of Br, for instance, is the same in KBr as in NaBr.

Employing numbers thus determined Kohlrausch has calculated the specific conductivities of a number of salts in dilute solution; and the calculated and observed values show a satisfactory agreement.

4. As the strength of the solution increases the specific molecular conductivity slowly diminishes. It may be approximately represented by the formula

$$k/m = A - Bm^{-\frac{1}{3}}$$

aud since $m^{-\frac{1}{3}}$ = the relative mean distance r of the molecules,

$$k/m = A - B/r,$$

or "the specific molecular conductivity is equal to a constant diminished by a quantity inversely proportional to the mean distance of the molecules."

5. The rate of diminution of k/m with increasing concentration is greater the higher the valency of the ions. This is ascribed to two possible causes—(*a*) a change in the constitution of the polyvalent ion, in virtue of which it approximates in behaviour to a monovalent ion, as the dilution increases; (*b*) the possibility that the current may be in part conveyed by the water of the solution.

6. The specific conductivity of a salt appears to be unaffected by its possessing, or being destitute of, water of crystallisation.

The above conclusions refer only to neutral salts; acids and alkalis (including alkaline carbonates) behave in a different manner. The chief facts collected by the author regarding these substances are—

1. The specific molecular conductivity of acids and alkalies is small if the dilution be very great, increases with the strength of the solution up to a certain maximum, and from this point diminishes as the concentration increases. The small initial value of k/m he considers (following Arrhenius and Ostwald) to be a secondary phenomenon—probably due to impurities in the water—and accordingly he neglects this part of the curve, and obtains the limiting value of the specific molecular conductivity by producing the second part backwards through the maximum to the line of ordinates. He thus obtains as the maximum limiting velocity of the ions 0·4 *mm/sec*, under and electromotive force of 1 volt per linear millimetre.

2. The alkalies KOH and NaOH have specific molecular conductivities differing by a small constant amount, as also have their carbonates.

3. The monobasic mineral acids have the same specific molecular conductivity. Phosphoric acid gives a nearly identical value if, instead of the equivalent $\frac{1}{3}H_3PO_4$, we employ the whole molecule H_3PO_4.

4. Acetic acid and ammonia in dilute solution exhibit a specific molecular conductivity nearly proportional to $m^{-\frac{1}{2}}$. In strong solution they conduct very badly.

5. Sulphuric acid is anomalous, exhibiting three maxima and two minima. The first minimum corresponds to the hydrate $H_2SO_4.H_2O$, and the second to concentrated H_2SO_4. One of the maxima occurs between this point and SO_3. This behaviour points to a chemical change in the structure of the molecule depending on the concentration.

With regard to the problem of electrolytic conduction in general, Kohlrausch lays down the axiom that no electrolyte in a pure state is a good conductor, but only becomes such on admixture with other bodies, this admixture being necessary in order to set up the dissociation which Clausius looks upon as the cause of migration of the ions. In this connection the question is discussed as to whether the water of a solution conducts part of the current. This our author considers extremely likely, as such a circumstance would explain various anomalies.

Kohlrausch discusses Bouty's "law of equivalents," which states that "the electric conductivity of dilute salt-solutions of equivalent strengths is the same for different substances." Bouty distinguishes between "normal" salts, which obey the law, and abnormal salts, which do not; and defines an abnormal salt as one "whose constituent ions in dilute solution travel with different velocities." But Kohlrausch shows that some salts which would come under this definition obey Bouty's law, while some of the salts which disagree with it can be shown to be "normal," from observations on their migration-constants. He also objects to the law on the ground of its inherent improbability, and alleges further that Bouty's method of calculation is erroneous. The cases, therefore, of agreement with the law he looks on as coincidences.

Among minor points of interest brought out by the investigation are the following:—

1. The low conducting power of nearly pure water, the smallest value obtained being $0·25 \times 10^{-10}$.

2. The phenomenon of absorption by the electrodes. The conductivity of a very dilute solution of HCl was found to slowly diminish owing to the withdrawal of the acid from the solution. That this is due to the electrodes was shown by an increase in the resistance on sinking them in the fluid, the higher conductivity being restored by stirring. The phenomenon is not exhibited by solutions of neutral salts.

3. The specific molecular conductivity of a strong base or acid is diminished by gradual neutralisation, reaches a strongly defined minimum when neutralisation is complete, and thence increases. Phosphoric acid shows several such minima; acetic acid gives a curve of *gradually* changing curvature, the neutralisation point being apparently somewhat indefinite.

ON CONTINUITY OF ELECTRIC CONDUCTION.*

BY DR. HOPKINSON.

In my experiments on residual charge I touched upon the second question in Lodge's programme ("Is Ohm's law obeyed by very bad conductors?")†, and pointed out that Ohm's law could be regarded as a limiting case of a more general law of superposition. In the case of mechanical after-effects the law of superposition does not hold, even approximately. The fourth question ("Is there any relation between optical opacity and electrolytic conductivity?") appears to me to be very intimately associated with the fact that bodies which, if they conducted, would be electrolysed do not follow Maxwell's law, whereas some other insulators do. My own present impression is that an electrical displacement in glass may, although continuous, be roughly divided into four successive stages. 1st. A yielding of the dielectric during a time corresponding to the time of wave frequency of light, for which $K = 2\frac{1}{2}$ about. 2nd. A further yielding during a time corresponding to great absorption below the red, bringing K up to from 6 to 10. 3rd. A further slow yielding, partly recoverable, hardly sensible in time less than a second or such like, and going on with diminishing amount for days. 4th. A yielding corresponding to an actual decomposition of the material. Superposition probably applies to all these continuously connected successive events. Probably if we could experiment fast enough on any ordinary electrolyte, like solution of $CuSO_4$, we should find a similar succession of phenomena.

[Dr. Hopkinson's note is of extreme interest, and the references to his papers are as follows:—"Residual Charge in Leyden Jar," *Phil. Trans.*, January 1877; "Strain in Glass Fibre," *Proc.* Royal Society," October 4, 1878; "Refractive Index and Specific Inductive Capacity, *Phil. Mag.*, April 1882. This last paper I may abstract thus:—

Maxwell's laws are that $\mu^2 = K$, and that transparent bodies

* Communication to the British Association Committee on Electrolysis.
† A programme of suggestions issued to the British Association Committee on Electrolysis.

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must insulate. They are true for mineral oils and solid paraffin; not true for glass, Iceland spar, and organic oils. Consider, for instance, light flint glass: K is 6·7 for disturbances whose period is longer than 10^{-5} second, and for these disturbances it behaves as an insulator. It ought, therefore, for such waves to be transparent, and to have an index 2·6. But, for disturbances of period about 10^{-15} second, its index, reckoned for very long waves by extrapolation formula, comes out about 1·5. Is there any way of accounting for this discrepancy? Yes; perhaps by the known fact that on waves *between* these two periods glass exercises a strong selective absorption, and that this is usually accompanied by anomalous dispersion, which at once renders all empirical reasoning towards the state of things for very long waves, from the observed condition for very short waves, utterly futile and misleading. Perhaps, therefore, Maxwell's law is after all obeyed by these substances for long waves, and one way to test the question is by using rays from a thermopile to a freezing mixture.

O. L.]

ON THE ELECTRIC RESISTANCE OF MAGNETITE.

BY PROF. SILVANUS P. THOMPSON, D.SC.

This is a preliminary note on a research begun with the view of elucidating the question whether the conduction exhibited by various mineral ores and metallic oxides and sulphides possessing quasi-metallic conductivity is or is not accompanied by electrolysis. The substance selected, magnetite or magnetic iron ore, is a thoroughly good conductor, as is evidenced by the simple fact that if a piece of it be interposed in the circuit of an ordinary electric bell the bell can be rung through it.

The sample selected was a fine homogeneous piece of ore from Arkansas, and was reduced by the lapidary's wheel to parallelipipedal bar. Its total length was 5·53 centimetres, its breadth 1·52 centimetre, and its thickness 1·27 centimetre.

The bar was placed between electrodes of platinum foil, which were clamped against its end-faces by means of screws; it was then placed in a bath of paraffin oil, enabling it to be heated to any desired temperature up to 135° C.

To test for electrolytic polarisation a current of about 1 ampere was passed through it from three nitric acid cells for some minutes. On stopping the current there appeared a slight polarisation, not, however, exceeding 0·0005 volt, and therefore of an order indicating a thermo-electric rather than an electro-chemical origin.

The specific resistance was then measured by observing the fall of potential between two marked points 3·22 centimetres apart upon the bar, and comparing this with the fall of potential between the two ends of a standard resistance coil, intercalated in the same circuit. The resistance was found to diminish very remarkably as the temperature was raised. Observations were made at intervals of from twenty to forty minutes apart, with the following result:—

Temperature (C.)	Resist. of centimetre cube in B.A. units.
23°	0·719
54°	·709
79·5°	·505
107°	·416
133°	·287

It appears that the resistance of magnetite agrees with that of carbon and the electrolytes in possessing a negative temperature coefficient.

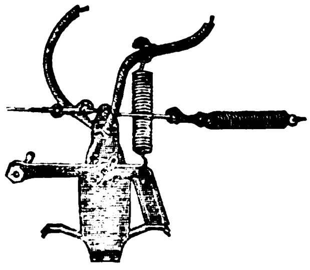
A somewhat longer and thinner bar of hæmatite prepared for future experiments showed a resistance of about 108 megohms, which in a preliminary heating fell to 81 megohms.

The determinations were made by the author's chief assistant, Dr. R. M. Walmsley.

ELECTRIC "CONDUIT" TRAM LINES.

By the term "conduit" tram lines we may distinguish that system in which current is supplied to the electric motor by means of a trailing collector, running upon an insulated cable placed in an open conduit, which is sunk in the centre of the line. For electric street tramways this is the only system which promises to be able to compete with the use of secondary batteries. Mr. Holroyd Smith is, as is well known, the chief exponent of this system, and, so far as we are aware, with the exception of the Blackpool line, there is only one other example of the system at present in operation. This is to be found in a line at Philadelphia, which has been constructed by Mr. Schlesinger. At the meeting of the Franklin Institute, on October 20th, the details of this line were described at length. It appears, however, that of the three points of chief interest, namely, the method of regulation, and the construction of the conduit and of the collector, only the latter has at present received a final solution, the two former being avowedly of a temporary character. Nevertheless, the line is running very successfully, though only one car is at present at work. The form of collector which experience has shown to be most suitable is shown in the accompanying figure.

It should first be stated that Mr. Schlesinger does not employ the rails as a return, but prefers to use two insulated copper cables—or, rather, strips—both of which are placed in the same conduit. The collector consists of a cast-iron frame, which carries a strong finger to remove obstructions from the slot. This frame is secured by means of a bolt to the car, in such a manner as to allow it perfectly free motion in a vertical and sufficient in a horizontal plane. Through a fork in the frame a phosphor-bronze casting passes, fastened to it by means of a bolt, so as to swing freely in a vertical plane and to have enough side-play. This casting passes into the slot, and carries two steel springs well insulated from it and from each other. A strong spiral spring, which takes up all the irregularities in the motion of the car, presses the springs against the conductors. To furthermore insure good conduct, the phosphor-bronze casting is connected by springs and wire ropes to a lever on the front platform. With this lever the casting is



The Collector.

tilted in such a manner that in going forward the front parts of the contact-springs, and in going backward the back parts are moved away from the conductors. Two such collectors are supplied to each car, one having the cast-iron finger pointing forwards, the other backwards. The connection between the contact springs and the motor on the car is made by means of well-insulated wires, protected where they pass through the slot by steel plates riveted to the phosphor-bronze frame.

The E.M.F. employed is somewhat low for this class of work, being only 160 volts; the current on the level is between 15 and 17 amperes; on an incline of 1 in 30 this increases to 45 amperes. The empty car weighs 7,100lb., and it carries forty-five passengers, which probably brings the total weight, when fully loaded up, to about 6 tons.

DUPLEX TELEPHONE CIRCUITS.

The telephone lines connecting New York and Philadelphia have recently been duplexed by a method due to Mr. J. Barrett, of Brooklyn. The duplexing of telephone circuits has already been accomplished in America upon a method the principle of which consists in the use of a metallic circuit in combination with an earth circuit. One set of instruments is worked upon the metallic circuit in the ordinary manner, and the two wires form a common line with respect to the earth circuit in which the other set of instruments is placed, suitable resistances being inserted to maintain a balance in each circuit.

There are certain difficulties encountered in this method of operating, which consist in the fact that a considerable portion

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of the energy of the current traversing the circuit is dissipated in overcoming the balancing resistances, and the current is necessarily so subdivided that its action upon the receiving magnets is of a very limited nature.

The following description of the method now adopted on the New York and Philadelphia Line is taken from the *Electrical World* of New York:—Mr. Barrett's system, broadly stated, consists in bringing the metallic or double wire instruments at the terminal stations into inductive relation by means of converting or repeating induction-coils with both sides of the circuit, instead of connecting them directly with that circuit by means of a bridge-wire. The currents traversing the metallic circuit are thus economised, inasmuch as they are only required to traverse a direct circuit, while the accompanying currents, which are initiated in the earth branch at either terminal station to actuate the corresponding receiving instrument in the distant earth branch, cannot affect the intermediate double-wire instruments, as the current generated by the earth-branch transmitters at any given instant acts upon both sides of the double-wire receivers alike, the current induced in one converting coil being opposite in direction to that induced in the other at the same instant, so that its effect is thus neutralised by its own action.

Mr. Barrett provides a double-wire line circuit, and at the terminal stations includes in each wire of the circuit an induction coil wound with two insulated wires side by side, one of which wires is directly in circuit with the double wire line, while the other is connected in circuit with the secondary helix of a telephone transmitter and with the coil of a telephone receiver. Thus messages from a distant station reach the receiver by means of induction through the converting coils, one of which is in the direct and the other in the return wire, while messages spoken in the transmitter develop currents in the secondary circuit of its induction coil, and these again by induction develop tertiary currents of coincident direction with one another in both converting coils simultaneously, which currents, being of like direction, re-enforce one another and travese the line to act through like converters upon the distant receiver. To a point of the metallic circuit at each terminal station, equidistant from the converting coils, an earth branch is attached, including the usual telephone instruments. Telephonic currents developed in the transmitters at either terminal station in the earth branches will traverse both direct and return wire in the same direction; that is, in relation to any intermediate point or appliance the current in both lines will be at any given moment positive or negative; hence, while the receiving telephone in the distant earth branch will readily respond to their action the intermediate instruments will be totally irresponsive, for the reasons stated above.

In the accompanying diagram of circuits, Fig. 1 represents the plan adopted of inductively connecting the metallic circuit instruments primarily. As will be seen, there are at each station two converting induction coils, 1 and 2, the two insulating wires of which, of identical gauge and length, are wound together, so that each conductor is in close inductive proximity to the other throughout its entire length. One of the conductors, 3, of the converting coils is included at each station, as shown, in the circuit of the direct wires w and w', so that the conductors of each coil are virtually placed in direct circuit serially with the line. The other conducting wires 4 of the coils are joined up in a local or home circuit comprising the receiving or magneto telephone t and the secondary helix of the transmitting telephone induction coil T, the latter being operated in the usual manner through the intermediation of the primary helix by the transmitter 7 and battery 8. The local circuit may be traced as follows:—Wire 4 of converting coil 1, secondary transmitter coil T, receiving telephone t, wire 4 of converting coil 2, and thence by conductor w^2 back to the starting point. The route of the main circuit in like manner may be traced from an arbitrary starting point, z, at station A, through wire 3 of converting coil 2, line wire w, through the converting coils 1 and 2 at station B, and back *viâ* line wire w' and through coil 1 at station A, back to the point z. Each converting coil is provided with a soft iron magnetic core, which is adjustable with respect to the extent of its insertion in the helix spool, for a purpose which will be described below.

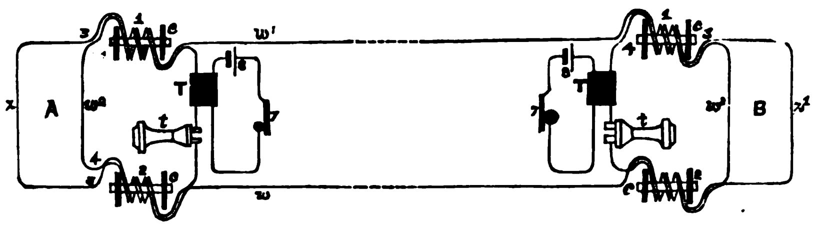

Fig. 1.

Fig. 2 shows a metallic circuit with its appliances similar in every respect to the circuit and arrangement described in Fig. 1, but with the addition of an earth branch extension-circuit at both terminal stations. This branch w' is at both ends united to the double wire circuit at a point z or z', equidistant from the two converting coils 1 and 2, and passes through the regular telephone instruments to earth at g. This earth-branch extension may of course be constructed of any convenient length extending to the stations G and H, which may be located at a considerable distance from the points z and z'.

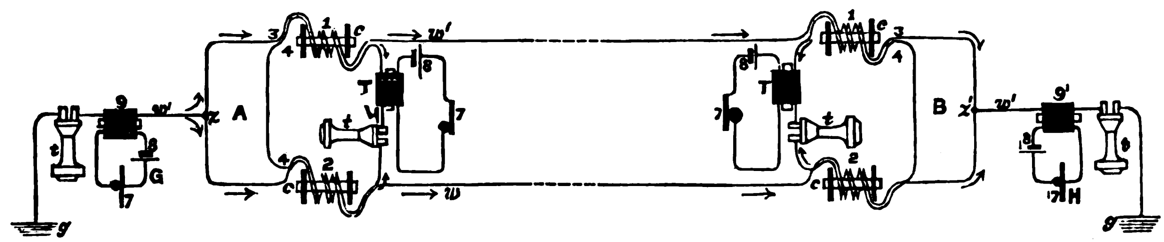

Fig. 2.

The telephone instruments shown at each of these stations G and H consist in this case of a receiving telephone t, and a transmitter 7, in a primary circuit including a battery 8, con-nected with the branch line w' through its induction coil 9.

The instruments in both terminal branches are alike, and a description of one will thus serve for both.

Mr. Barrett has found in practice that stations A and B may freely exchange oral communications without affecting the instruments at stations G and H, and that G and H may in like manner communicate without interfering in any way with messages which may simultaneously be in course of transmission between A and B.

The usual signalling appliances are of course in practice combined with the above system, as will be readily understood.

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SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The first meeting of the winter session of this society was held at the Institute of Civil Engineers last night, when Mr. Gisbert Kapp read a paper "On the Predetermination of the Characteristics of Dynamos," which we give *in extenso* below. Mr. Kapp, in his opening remarks, pointed out that Drs. J. and E. Hopkinson had practically covered the same field in their paper, which has just been published by the Royal Society, but his own paper had been written before their work became known. The discussion which followed the reading of the paper will be resumed at the next meeting of the society. In the meantime we shall give here some interesting and important facts which were communicated by Prof. Ayrton, reserving the remarks of the other speakers until the completion of the discussion.

Professor Ayrton congratulated Mr. Kapp upon having succeeded in developing a sound working theory of magnetism and magnetic induction, in place of the mathematical abstractions which hitherto went by that name. He particularly referred to the results obtained by Professor Rowland, which had not been confirmed by any experiments of his own, or, so far as he knew, of others. At the time when Mr. Kapp read his important paper on "Dynamo Electric Machinery," before the Institute of Civil Engineers, it happened that his colleague, Professor Perry, and himself were working on the same subject of magnetic resistance; and some months ago they had already prepared a paper upon the subject. At the period of Mr. Kapp's first paper they did not feel quite satisfied that the formula in which he expressed the magnetic flow by dividing the excitation by the sum of three magnetic resistances, belonging respectively to the iron in the field, the iron in the armature, and to the air gap, did accurately represent the true state of the case. What was termed leakage did undoubtedly exist for all degrees of magnetisation, even the lowest. It therefore seemed necessary to take into consideration the magnetic resistance of the whole of the air by which the magnet was surrounded, and not merely that between the poles and the armature. The question then arose in their minds whether the true expression for the resistance of a magnetic circuit containing an armature was not one in which the resistance of the iron and the air space was treated as one path, *combined in parallel with another path whose resistance was represented by that of the whole of the surrounding air.* In this way the case of any number of armatures whose resistances were separately known could be represented by formulæ precisely similar to those for parallel electric circuits, when the resistance of the surrounding air was included as one of the paths. Upon appealing to experiment these views received decided confirmation. Moreover, even for low degrees of magnetisation the resistance of the air was found not to be so large as had usually been assumed in comparison with that of the iron. For instance, in one case in which a horse-shoe electro-magnet had itself a resistance represented, in certain units, by the figures 0·5082, that of the air surrounding it was only 3·125; and that of an iron armature 5in. in length and separated from the poles by a 1-32nd gap was 3·697. Another peculiar result was that the magnetic resistance was apparently exactly the same, whether the armature was placed in a position corresponding to that usually assumed to be in the natural line of magnetic flow, or whether it was at right angles to that position.

[In Mr. Kapp's paper below we are unable to reproduce the figures, but our readers will not on that account find any difficulty in following the author.]

THE PRE-DETERMINATION OF THE CHARACTERISTICS OF DYNAMOS.*

By Gisbert Kapp, Associate.

If we know the number of magnetic lines of force which pass through the cross section of the armature core at the neutral points, the internal electromotive force developed can easily be calculated from the winding and the speed. Adopting, for convenience of calculation, as a unit line that which is equivalent to 6,000 lines in the C.G.S. system of measurement, we have

$$E_a = z_1 N t n 10^{-6},$$

where E_a is the E.M.F. developed, z_1 the number of unit lines passing through both neutral sections, $N t$ the number of conductors counted all round the armature, and n the speed in revolutions per minute. This formula applies equally to cylinder, disc, and drum armatures, but in the former two types $N t$ represents the number of complete convolutions on the armature, whilst in the latter it represents twice that number. The formula also applies equally to bipolar and multipolar machines, the only difference being that in the latter cases the neutral sections to be considered are not diametrically opposite.

The question to find the E.M.F. of a given armature therefore resolves itself into the determination of z_1, the number of lines passing through the armature core; and in the following I would submit a suggestion for the solution of this problem, if the constructive details of the machine, the exciting power, and the quality of iron are known. Stated in other words, the problem is to construct the characteristic curve of a dynamo from its drawing without having recourse to experiment.

Since the usual characteristic representing the relation between exciting current and electromotive force depends on the speed, it is more convenient to use the characteristics of magnetisation, where abscissæ represent exciting power and ordinates the number of useful lines. As far as I am aware, the only attempt to represent the relation between these quantities mathematically is the ingenious and very simple formula by Fröhlich, which has been further developed by Prof. Silvanus Thompson. According to the original notation of Fröhlich the effective magnetism (M) is represented by

$$M = \frac{i}{a + b\,i},$$

where i is the current of a series-wound dynamo (therefore proportional to the exciting power), and a and b are constants to be determined experimentally for each machine. For an infinite current the magnets become saturated, and the effective magnetism equals $\frac{1}{b}$. If now absolute saturation be considered as unity, and actual magnetisation be expressed in reference to it, the formula is further simplified to

$$M = \frac{i}{a + i}.$$

In this case the constants to be determined experimentally are a and the E.M.F. corresponding to saturation. In Prof. Thompson's well-known modification of this formula, $H = \frac{G \kappa S i}{1 + \sigma S i}$; there are also two constants which require experimental determination—G, the geometrical constant depending on the configuration of the machine, and the saturation coefficient σ "which is the reciprocal of that number of ampere turns that will bring the magnet up to such a degree of saturation that its susceptibility is halved."

Now this necessity of making at least two experiments in order to determine the value of the constants in each particular machine limits the use of either formula to such cases where the new machine differs from that experimented upon in the winding only, but not in size or type. There is another drawback. Fröhlich himself says that his formula only gives correct results if used between limits for which his "curve of current" can be considered as a straight line, and, generally speaking, it will therefore not be possible to construct the whole of the characteristic of magnetisation, even if we have made the necessary experiments for the determination of the constants.

It was with a view to do away with preliminary experiments of the nature alluded to that about two years ago I began to make use of a formula by which the strength of field could be determined from the electrical, magnetic, and mechanical data for each design of dynamo. This formula is based on the conception of magnetic resistance—a quantity proportional to the ratio of length divided by area, and in so far analogous to electrical resistance, but differing from the latter in this respect, that the co-efficient with which the ratio of length to area must be multiplied (the specific resistance) is not a constant, but varies with the density of lines flowing through the iron, and reaches infinity at absolute saturation. As regards air or non-magnetic metals this coefficient is, however, assumed to be a constant. The formula, as published by me in a paper read last year before the Institution of Civil Engineers, is

$$z_1 = \frac{P}{R_a + R_a + R_f},$$

where P is the exciting power in ampere turns applied to the horseshoe magnet which produces the lines z_1, and R_a, R_a, R_f, are the magnetic resistances of the air space, armature, and field-magnet respectively. The resistance of air space is found by multiplying twice the interpolar distance given in inches (twice because the lines must leap into *and* out of the armature) with the constant 1440, and dividing the product by the polar area. In this case the numeric 1440 is the specific magnetic resistance of air in the arbitrary system of measurement we have adopted. The other two resistances are for very low degrees of magnetisation, found in like manner by determining from the drawing of the dynamo the average distances through which the lines flow in armature and magnet, and dividing by the respective areas; the ratio in each case being multiplied by the numeric 2, which represents the initial specific magnetic resistance of annealed wrought iron. The above empirical formula is only correct for low degrees of magnetisation, and consequently for comparatively weak exciting powers. Assume we have made the calculation and determined the ratio (represented by a straight line) between E_a and P for a given speed. If we now work the dynamo under these conditions, we find that the actual E.M.F. observed is either equal to or slightly higher than the calculated E.M.F., but seldom lower. In other words, the actual initial value of the magnetic resistance is either equal to, or slightly less than, the calculated value. This is probably due to the neglecting of the influence of edges of pole-pieces, and to errors in estimating the lengths and areas of the flow of lines. Nature finds the easiest way for this flow, and since it is obviously impossible for us in our calculation to hit on a still more easy way, we are likely to obtain (when working with the greatest possible

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care) a slightly higher resistance. The error is, however, generally very small, and is of no influence on that part of the curve which is of practical importance.

Before entering into the question of how this part of the curve can be obtained, it will perhaps be best to illustrate by analogy to the voltaic circuit the conception on which the formulæ to be given are based. Let, in Fig. 1, R_a represent a certain resistance (corresponding to the magnetic resistance of the armature core), connected by resistances $\frac{R_a}{2}$ representing the two air spaces) with the poles (p p) of a voltaic battery having a resistance R_f (corresponding to the field-magnet) and an internal electromotive force P (exciting power).

Imagine at the first the apparatus well insulated, then the current z_1 is given by the ratio of P and the sum ($R_a + R_a + R_f$).

If now the battery be submerged into a badly-conducting medium, currents will flow as shown by the dotted lines, and consequently through certain cells a current flows which is larger than the useful current in R_a. It is impossible to say exactly in what manner these currents of leakage are distributed, but it is evident that the most serious loss must occur between the poles where the difference of potential is a maximum, and that in a given medium and arrangement of battery the total loss through leakage can be considered as approximately proportional to the difference of potential between the poles. Let the latter have the value p_1, then the current lost, ζ, equals p_1/ρ, if by ρ we represent the average resistance of the surrounding medium for this particular configuration of battery. We can also, with fair approximation, put the current in the battery—

$$z_2 = z_1 + \zeta.$$

Now imagine that by some means we can give to the electromotive force (P) of the battery any value between zero and that value which will produce the maximum current (z_1) required. It will then be possible to determine what electromotive force is required for each value of z_1 between zero and maximum. To do this we proceed as follows:—We determine first the difference of potential at the poles—

$$p_1 = (R_a + R_a) z_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

then the loss by leakage—

$$\zeta = \frac{p_1}{\rho} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

then the total current—

$$z_2 = z_1 + \zeta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

then the loss of electromotive force (p_2) occasioned by the internal resistance of the battery—

$$p_2 = R_f z_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and, finally, the total E.M.F.—

$$P = p_1 + p_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The submerged battery is analogous to a horse-shoe magnet, since the latter is always surrounded by a medium which allows the passage of magnetic lines. To the electromotive force of the battery corresponds the total exciting power applied to the magnet; to the currents z_2, z_1, and ζ correspond numbers of lines respectively created within the magnet core, passing through the armature, and lost by leakage; the analogy of resistances has already been mentioned.

Since for small degrees of magnetisation the resistances of armature and magnet are not very different from their lowest initial values, which are very small in comparison with the resistance of leakage, it follows that for the early stages of magnetisation leakage has very little influence on the exciting power; in other words, that the creation of leakage or waste field does not materially increase the expenditure of energy required to produce the useful field. For a more intense magnetisation, such as found in the usual working conditions of dynamos, the case is, however, very different. In the first place, the resistance of the armature has now considerably increased, and with it has increased at a still faster ratio p_1, that portion of the exciting power (or magnetic pressure at the field-poles, if I may be allowed to use a somewhat unscientific term) which is necessary to force the lines through air space and armature. The immediate result is a large increase of the waste field, which has to be provided for by the magnet; augmenting, therefore, the density of lines in the case of the latter considerably beyond the value which would otherwise correspond to the useful field. Hence large increase of magnetic resistance, and consequently also of exciting power. This fact—that the number of lines created must be sensibly greater than the number utilised—explains at once the necessity of making the area of the magnet core considerably larger than that of the armature core. If, with a view to get an equal density of useful lines in armature and field, and thus save weight, the cross section of the magnet be reduced to that of the armature, it will be found absolutely impossible to saturate the latter, no matter how much exciting power we put on. A machine so constructed would therefore be a failure, not only on account of lower voltage, but also because it could not be compounded. Dynamo makers have long ago found out by practical experience that to produce machines of high voltage as compared to the length of wire on the armature, and machines that by reason of their rising characteristics can satisfactorily be compounded, it is necessary to work with a high magnetic density in the armature and a low density in the field. Roughly speaking, if we only take the useful lines into consideration, the ratio is from 1 to ·5, to 1 to ·6.

Before the formulæ (1 to 5) can be used for the actual determination of total exciting power as a function of the number of useful lines in any given dynamo, it is necessary to make an assumption regarding the rise of magnetic resistance with increasing density of lines. Whatever may be the mathematical connection between these two quantities, it must be of such a nature that for low densities the rise of resistance is insignificant; whilst for a certain and definite maximum density, the exact value of which depends on the nature of the iron, this rise is infinity. Amongst the formulæ which might be devised to fulfil these conditions two fairly simple expressions naturally suggest themselves—the one where the increase of resistance is made proportional to the reciprocal of the difference between saturation density and working density, and the other where it is made proportional to the tangent of an arc which represents the degree of saturation to such a measure that 90deg. corresponds to absolute saturation. The value of either of these two assumptions, or of any other which might be suggested, cannot be argued out on theoretical considerations, as we know as yet too little of the laws of electro-magnets. The only way is to apply either theory to machines actually tested, and then see which fits in best with practical results. In this way I have found the tangent formula to give better results than the other, and to fit actual experiments with sufficient accuracy for practical work. Without pretending to give a scientific reason why this formula should be better than any other, it might be pointed out as at least plausible that a tangent function might enter into the relation between exciting power and magnetisation. If we assume the act of magnetisation to consist in the bringing of molecular magnets into approximate parallelism with the lines of force passing through the metal, whilst the force resisting magnetisation—which might be a passive one of molecular friction or an active one of inter-molecular attraction or repulsion—tends to turn the molecular magnets away from that position, we can consider each molecular magnet as the needle of a tangent galvanometer having a field of its own and a zero position which may possibly be different from that of its neighbours. Whatever the configuration of these molecular magnets may be, it is at least conceivable that the average angle through which they have been rotated is equal to that of a molecule which started from a position at right angles to the direction of the magnetising force, and that therefore the tangent of this angle is a measure for the current, or, rather, for the exciting power surrounding the core. The weak point of this theory is that it does not show why the angle of rotation should be proportional to the number of lines created, and therefore I do not put it forward as a true, but simply as a possible, explanation.

Whether true or not, the fact of practical importance is that we can by the use of a tangent function determine the increase of magnetic resistance at various stages of saturation in such a way as to accord with experiment, and that therefore the same formulæ can be used for the construction of characteristics of new machines. The only data (besides those taken from the drawing) which we require to know are—

1st. Z_1, the maximum number of lines which can with an unlimited magnetising power be forced through the armature core.

2nd. Z_2, the maximum number of lines which can be similarly forced through the magnet core.

These are figures which depend on the dimensions of the cores and the quality of the iron, and if we could rely upon obtaining always the same iron, a few experiments made once for all would suffice for all future machines. Let the degree of saturation in armature and magnet be denoted respectively by σ_1 and σ_2, so that

$$\sigma_1 = \frac{z_1}{Z_1},$$

$$\sigma = \frac{z_2}{Z_2};$$

then the actual resistance in the armature core is obtained by multiplying the initial resistance by

$$\frac{\text{tang.} \left(\frac{\pi}{2}\sigma_1\right)}{\frac{\pi}{2}\sigma_1},$$

and similarly for the field-magnet.

From numerous experiments made with my own machines, and from data kindly supplied by some other dynamo makers, I am enabled to give the following average figures for the density of saturation to be taken as a basis when using my formulæ*:—

	Lines per square inch.
Armatures—charcoal iron wire well annealed	25
,, ,, ,, discs ,, ...	22
Field-magnets—hammered scrap ,, ...	18

The superiority of wire over discs is possibly due to better annealing, but probably to the fact that in wire cores the lines run mostly in the direction of the fibres, whilst in disc cores they run as often across the fibre as with it. The inferiority of field-magnet iron as compared to armature iron is probably due to the difficulty of thoroughly annealing large masses. I have no records of experiments made with machines having field-magnets composed of thin laminæ. Perhaps some of the members present can give their experience on this very important point. It will be noticed that the figures here given, although by no means the highest which can be obtained with exceptionally good iron, are considerably higher than the maximum induction obtained by the important experiments made independently by Rowland, Bosanquet and Hopkinson.

The only explanation which suggests itself to me is that the samples experimented on by those scientists were not so good as the usual commercial iron now obtainable for dynamos. Suppose, then, that we know the quality of our iron and its density of saturation. This gives us the values of Z_1 and Z_2. We now proceed as follows:—We assume a certain number

* These figures are not to be taken as generally applicable, but simply as *averages* of the usual qualities of iron now obtainable.

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of useful lines (z_1), and calculate the corresponding density (σ_1) in the armature core. The corresponding value of the function tang. $\left(\frac{\pi}{2}\sigma_1\right) / \frac{\pi}{2}\sigma_1$ (taken from a table prepared beforehand) is then multiplied with the initial resistance of the armature core (R_a), and added to the air resistance. The sum is multiplied with z_1, and thus we obtain p_1, the quantity which above was called the magnetic pressure between the pole pieces. The leakage of lines takes place under this pressure, and to obtain the exact number of the waste lines we must know the resistance of the space surrounding the machine. This resistance cannot be calculated in the same manner as that of the air space—so much depends on the configuration of the magnets on neighbouring portions of the iron bed plate, bearings, &c.; but from the character of the resistance of a non-magnetic medium it is evident that for similar types of a dynamos the value of ρ is inversely proportional to the linear dimensions of the machine. Thus this resistance can be found by dividing a constant by the diameter of the armature. An experiment made once for all is sufficient determine this constant for all sizes of a given type. Knowing ρ, we find the waste field $\zeta = \frac{p_1}{\rho}$, and the total number of lines created $z_2 = z_1 + \zeta$. The ratio of z_2 to Z_2 gives us the density in the magnet σ_2, and by again referring to the table we find the corresponding value of the function tang. $\left(\frac{\pi}{2}\sigma_2\right) / \frac{\pi}{2}\sigma_2$, with which the initial magnet resistance must be multiplied in order to obtain the actual resistance at that particular density. The product of this actual resistance with z_2 gives the exciting power (p_2) necessary for the field-magnet alone, and the sum of p_1 and p_2 is the total exciting power (P) necessary to produce z_1 useful lines. In this way we proceed to calculate P for various values of z_1, and, plotting the results in a curve, we obtain the characteristic of magnetisation, by the aid of which all the working conditions of the dynamo can be found. When determining the E.M.F. of the armature whilst a current is passing through it, account must be taken of self-induction, which has the effect of apparently lowering the characteristic. As this action does, however, concern more particularly the armature, and not the field-magnet, it does not belong to the subject of the present paper. To show the degree of approximation in calculating the exciting power in the manner above described Figs. 2, 3, and 4 have been prepared. These diagrams contain the calculated curves for three different dynamos, whilst the points indicated by little circles are values obtained in actual test of these machines. The lower curve in Fig. 2 is the predetermined characteristic of one of my own dynamos. It shows the number of useful lines passing through the whole armature as a function of the exciting power. The upper curve shows the total number of lines created. The ordinates between the two curves represent, therefore, loss by leakage. In order to enable anybody to check the correctness of these and the other curves, the data on which they have been obtained are given in a table below. The experimental points shown by little circles have for this dynamo the following values :—

z_1 =	715	1330	1490	1705
P =	3800	8600	10800	18600

By the courtesy of Messrs. Patterson and Cooper, and Messrs. Crompton and Co., I have been able to test these formulæ on their machines, and the result is given in Figs. 3 and 4 respectively. The curves shown in full lines are predetermined characteristics, showing the number of useful lines flowing through one half of the armature. (These machines, "Phœnix" and "Crompton," are of the double magnet type.) The experimental points in Fig. 3, which were kindly supplied to me by Mr. Esson, have the following values :—

$\frac{z_1}{2}$ =	207·5	594	792	910	1030	1070	1130
P =	1604	3840	5660	6900	9620	11240	12100

For purposes of comparison, a curve obtained by Fröhlich's formula has been added. This dotted curve shows values of $\frac{z_1}{2}$ obtained by using the function $\frac{P}{\alpha + \beta P}$, where α and β are constants which can be determined if two points of the actual characteristic are known. By choosing these two points near to each other a fair degree of approximation between the actual characteristic and Fröhlich's curve can be obtained, but only on that portion of the curve which lies between the points. Beyond it, on either side, the divergence is considerable. If one of the points is at $P = \infty$ (which would give, according to Fröhlich's new notation, the value of β as the reciprocal of the maximum magnetisation), the curve ought to be available from the chosen finite point up to saturation. In the diagram the finite point has been chosen at A, where P = 5,500, or about half the maximum exciting power which would be commercially profitable with this machine, since a larger power than 11,000 ampere turns would not produce any material increase of E.M.F. From the tendency of the characteristic, saturation has been assumed at $\frac{z_1}{2} = 1{,}150$. This gives $\beta = \frac{1}{1150}$ and $\alpha = 2{\cdot}32$. The dotted curve is found by using these values, and shows a considerable deviation from the points determined by experiment. By choosing the finite point A higher up the actual characteristic, a somewhat better accord between the latter and Fröhlich's curve could be obtained, but at the same time the range over which that curve can be used would be shortened.

As regards the curve of the Crompton machine (Fig. 4), the experimental points were kindly supplied to me by Mr. Swinburne, and have the following values :—

$\frac{z_1}{2}$ =	27	112	151	161	197	223	221	240	246	258	258
P =	1400	3300 & 3800	5300	5700	7700	8820	9050	10420	11300	12900	14060

The curves were found by using the following data :—

Table of Constants for the Three Dynamos Investigated.

Fig.	Z_1	Z_2	R_a	R_a	R_f	ρ
2	2200	2200	3·7	0·40	1·18	30
3	1200	1940	4·7	0·57	0·925	13
4	300	460	2·8	1·00	2·77	47

LEGAL INTELLIGENCE.

The Direct Spanish Telegraph Company (Limited) *v.* Bannatyne.

This was an appeal from the action which was fully reported in last week's *Electrician*, and which was heard by Vice-Chancellor Bacon, upon a motion by Mr. Neil Bannatyne, at one time Chairman of the Direct Spanish Telegraph Company (Limited), and now a preference shareholder in the Company, on behalf of himself and other holders of preference shares, against the Company, Sir James Anderson (its present Chairman), and the other Directors of the Company, for an interim injunction to restrain the defendants from acting on certain special resolutions passed by the Company for the reduction of their capital, and from presenting a petition to confirm the reduction.

Vice-Chancellor Bacon, having fully heard the case, granted the injunction asked for, with the right of appeal on the part of the defendants to a higher Court. Accordingly the case came on for hearing again on Wednesday afternoon in the Appeal Court, before Lords Justices Cotton and Fry.

Mr. Rigby, Q.C., and Mr. W. P. Beale (instructed by Messrs. Blunt and Lawford) represented the Company; Mr. Burton Buckley appeared for Sir James Anderson and the other Directors; Mr. Marten, Q.C., and Mr. H. B. Howard (instructed by Messrs. Murray, Hutchins, and Stirling) conducted the case for Mr. Bannatyne.

Mr. Rigby, in opening the case for the Company, briefly reviewed the nature of the previous trial, and the lines upon which the plaintiff's case had been conducted. He said that the real question that their lordships had to decide was whether a company could reduce its capital in cases where there were preference shareholders—whether, in other words, a case having arisen for the application of the statutory powers for reducing the capital, that power could be exercised with preference shareholders. In the present instance the case arose by reason of the total abandonment and picking up of the cable which formed part of the principal assets, so that a large portion of the original capital was no longer represented by available assets, and their lordships would have to determine whether in reducing that capital the preference shareholders were not liable to have their capital reduced *pari passu* with the others, and whether or not there was anything in the bargain with the preference shareholders which amounted to that. He ought to say at once that it was hardly a question of competition between preference and ordinary shareholders, for the reports of the Company's meetings went to show that the majority of the preference shareholders were in favour of the reduction proposed. Of course if it were *ultra vires* to do so, any one shareholder, as Mr. Bannatyne, had a perfect right to object. The company was formed in 1872, for the purpose, among other things, of buying the submarine cable which then existed between the Lizard and some places in Spain, near Bilbao. The price paid for the cable was about £112,000, and for some time the Company went on raising that capital. Later on they issued, under powers to which he would call their lordships' attention presently, preference shares. The main object of that was for the purpose of purchasing the line in the Mediterranean, between Barcelona and some point in France, and for other purposes. The real question then was, what was the arrangement between the preference shareholders and the company, and was there anything in it which precluded the application to this Company of those provisions for reduction which the Legislature had made generally in regard to all companies? He would first ask their lordships' attention to the words of the Memorandum of Association, and they would see the position in which the capital stood. The material Articles were few in number. Article 7 of the Articles of Association authorised the Directors, "with the previous sanction of a special resolution of the Company, to increase its capital by the issue of new shares to such an aggregate amount, with such preferential right to dividend, and such priority in the distribution of assets, or subject to such postponement of dividends, or in the distribution of assets, as should in such special resolution be provided." He did not think he would trouble their lordships with Article 8, but Article 9 provided that "all capital raised by the creation of new shares shall be considered as part of the original capital, and shall be subject to the same provisions in all respects as if it had been part of the original capital, except so far as these Articles, or the resolution authorising the raising thereof, may otherwise direct." Article 10:—"The Company may also, by special resolution from time to time, reduce its capital, including any capital that may be created, and alter the amount and denomination of the shares." He did not know that any more of the Articles were of great importance to the case, but he would direct their lordships' attention to Clauses 103, 104, and 105, which read as follows:—(103) "The Directors may, with the sanction of a general meeting, declare a dividend to be paid to the members in proportion to their shares, and to the amounts paid up thereon respectively." (104) "No dividend shall

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be payable except out of the profits arising from the business and property of the Company." (105) "The directors shall, out of the profits of the Company, provide a reserve fund to meet contingencies, or to form a sinking fund in aid of capital, or for equalising dividends, or for paying off by instalments or otherwise any subsisting mortgage or other debt, or for replacing, renewing, repairing, maintaining, or adding to the lines of telegraphic communication by land or sea, or the stations, apparatus, appliances, privileges, or other real or personal property connected with the business of the Company, or any part thereof, or for any other purpose connected with the business of the Company; and the Directors may invest the sum so set apart as a reserve fund, or any part thereof, upon such securities as they may select." The last provision was of vital importance to telegraph companies, seeing that they depended for their profits entirely upon the continuation in working order of their cables, and seeing that it was found by experience that cables did not last for ever, but might at any moment be stopped by being worn out, or become so much deteriorated as not to be worth repairing. They stood between two Acts. To reduce the capital in certain cases was permitted by the Act of 1867, and then the Act of 1877 added some legislation on the subject. The Articles he had read were the only ones referred to by the other side, and so far as he appreciated the case none of the others were of importance. He would now call their lordships' attention to the special resolution passed at an extraordinary general meeting of the shareholders, held on the 3rd of July, 1874, authorising the issue of the preference shares, such shares being "entitled to a fixed preferential dividend of 10 per cent. per annum," and further providing that if in any one year there was insufficient to pay the said dividend, it was to be made up out of the profits of succeeding years." Their lordships would see that the cumulative dividend, as it was called, was not confined to the profits of any one year, but the account could be carried on and the 10 per cent. would be added on, and the whole paid as soon as there was sufficient money to pay it with. What had taken place was this. It was known some time ago that the cable which they had originally purchased, and for which they had given £112,000, was in a very critical condition. It was not, however, known at the time whether it could possibly be repaired or not; but it was apparent that if the cable were lost they would be losing a valuable asset, and the question arose whether it was competent for them to go on paying dividends out of the current profits of the society from year to year without providing the means for making good that asset in case of accident. Counsel's opinion was taken, and it was pointed out to them that they must either lay by sufficient money to make up what was actually lost of capital to place themselves in a dividend-paying position, or they must reduce their capital by writing off, in fact, the asset that they lost, and that then they would be a dividend-paying Company. That was exactly what had happened by the loss of the cable. The matter was taken into consideration by the Directors, and after a great deal of consideration and vacillation they came to the conclusion that they ought to recommend the Company to reduce the capital, and he would call their lordships' attention to the resolution which was passed authorising the same. Mr. Bannatyne came to the meeting and argued the case on the one side, while the Directors put forth their views on the other, and then the voting was taken, which went in favour of the Directors' proposal. But undoubtedly Mr. Bannatyne was in the position, having voted against the resolution, to come to the Court and say, "You acted *ultra vires*." The resolution passed on the 30th of September, and confirmed on the 19th of October, 1886, was as follows:—"That in consequence of the abandonment of the Company's original cable, the capital of the Company be reduced from £190,000 (at present represented by 6,000 preference shares of £10 each, all issued and fully paid up, and 13,000 ordinary shares of £10 each, whereof 12.931 are issued and have £9 per share paid up, and 69 are unissued) to £95,000, and that such reduction be effected by writing off £5 per share from the amount credited as paid up on each issued share, and £5 per share from the nominal amount of each unissued share, the amount so written off the issued shares being capital not represented by available assets." There could be little doubt as to the fact—it had not been denied by his learned friend—that there was an amount of capital actually gone. It was not a question of speculation, because the Directors, after consulting with the shareholders, and with the consent of a general meeting, determined to pick up the cable and sell it as old material. They did pick up as much as they could, but it became a question with them whether they would get as much for selling it as would cover the expenses of picking it up. There was no doubt that the cable was no longer in existence. The whole question was whether the resolution was *ultra vires* or *intra vires*. They had had reports from electrical engineers, which had been laid before the Company, and which had been approved by the Company, and so far as the Company could settle the matter, they had settled it for themselves. Those reports distinctly said that the line could not be advantageously restored, and that an entirely new cable would have to be laid. By the Articles of Association the preference shares were part of the original capital of the Company in all respects—by virtue of the Clause 9—except in so far as the special resolution of the Company that created them made provision; and, being part of the original capital, the contention of the Company was that they were subject to Clause 10, which gave the Company power from time to time to reduce its capital. Was there anything in the special resolution to show that they were exempt by the terms of their bargain from Clauses 9 and 10 of the Articles? The only clause to be relied upon as amounting to an express variation was that in Clause 3 of the special resolution, which said that "the shares shall be entitled to a preferential dividend of 10 per cent. per annum, &c." It was quite true that in this particular instance it was provided that all the capital should be paid up on allotment; but he did not think that that was a clear construction of the clause, and for the purpose of construing it he would ask their lordships to say what it would have meant if the capital had been originally paid up by instalments. When they found that the scheme of the Company affected those shares as well as the others, except so far as it was altered by the resolution, gave dividends to the shareholders in proportion to the amount taken up, it would follow that if they had paid £1, £2, £3, £4, or £5, or any amount up to £10 on their shares, they would simply get 10 per cent. on the amount paid up. That was evidently the scheme of the Company. The provision in Clause 3 was not a provision that the preference shareholders should throughout all time receive £1 per share, which would be 10 per cent., and that they should have a preferential dividend of that amount, but that their dividend should be always a 10 per cent. dividend. That was the only bargain—that their dividend should always be a 10 per cent. dividend, and there was absolutely nothing to show that it was not so. The way in which the matter was argued in the lower Court was—"we (the preference shareholders) are entitled throughout all time to £6,000 a year as a first charge on the profits of the Company, and you are endeavouring to deprive us of that. In one sense that was true. If that sum were worked out it would be found that 10 per cent. dividend on £60,000 amounted to £6,000, but the true bargain confirmed in that clause was this:—"Your dividend shall always be a 10 per cent. dividend on your capital." But, on the other hand, the Company said that the capital was not a fixed but a varying quantity. They found that the Act of Parliament, passed in a perfectly general way, authorised all companies—given a certain state of things—that was to say, when there were no available assets to represent the amount to be reduced, as in this particular case—to write off that amount of capital. It was not stated with respect to one set of shareholders only. It was not said of companies in which all the shareholders were in the same position as regarded dividend. Nothing of the kind. That might be affected by a particular bargain in each particular case. If there had been an express bargain that there should be no reduction of capital, and they reduced the amount of dividend payable to the preference shareholders, that would have been a different thing, and if their lordships were to find anything in the contract to that effect, then he would bow to that decision. The whole of his argument, however, rested on this, that there was no such bargain, either expressed or implied, and that the actual terms of the contract, or the real meaning of it, amounted only to this: "Your dividends shall not be fluctuating; they shall not vary in amount; they shall not at one time be higher and at another lower. You shall always have on your capital for the time being, whatever that capital properly may be, a 10 per cent. dividend, and you shall have that as a first charge on the profits of the Company." Their lordships would again perceive that it was not by no means clear that the effect of the proposed resolution was against the interests of the preference shareholders. It was clear that if the Company had to make up a reserve fund, until they had supplied the capital that was lost it would take 10 years before the preference shareholders could get 1d. of dividend. After that time they might, but subject to the fact that the other cables—the other assets—were in such a condition as they might safely do so. He did not think it was for him or even for the Court to look too closely to the question of commercial advantage or disadvantage, but the Company gave a *quid pro quo* in the arrangement they wished to bring about. They paid 25 per cent. on the preference shares down on the nail in part payment of the arrears due to them, and the result would be that the preference shares would get, as things stood, a large amount of dividend in place of having the dividends postponed for a considerable number of years, and perhaps indefinitely; and besides they would get their 10 per cent. on the £5, which would represent their capital, instead of 10 per cent. on the £10. The real point, as it appeared to him, was—what was the bargain? If it was *ultra vires* to pass the resolution, it did not matter how many were in favour of it, any one could object to it. At the time when the Act was passed it was matter of common knowledge that it was the policy of the Legislature to allow reductions of capital. For his part he did not know how a reduction of capital could take place legally or effectually, except by reducing it equitably all round. He could imagine their adopting an alternative way as regarded a part of the capital, but practically they could not reduce it except it was all round. There was no doubt that the preference given by the clause was only as regarded dividend. The preference shareholders were to have a 10 per cent. cumulative dividend, but they had no preference as regarded capital. Supposing that the Company were wound up—supposing that their other cables were lost—the preference shareholders would at once come in and share *pari passu*, on the ground that they formed part of the original capital, in the distribution of the assets. And a total loss of capital was somewhat analogous, at any rate, to the case (which had arisen) provided for by Act of Parliament, which entitled a company to say, "We have lost part of our assets; *de facto* there is nothing to represent one-half of them, and therefore we avail ourselves of the powers of the Act to write off that part of the capital which is not represented by available assets." They were only recognising in a legitimate manner, and in the way in which they were meant to do it by Act of Parliament, that one-half of the capital had gone. *De facto* there was not £10 worth of property in existence to represent each of the orignal preference share, but only £5 worth. But, although that capital had partially disappeared, the Act of Parliament pointed out in what way, by special resolution, and so on, they could make that reduction in their capital which was required to make it square with the facts. They held that it was part of the bargain that the Company might reduce its capital. It must not for a moment be forgotten that at the time the capital was issued it was only the Act of 1867 that was in force, but that gave the Company power by every lawful means to reduce the

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capital. Of course they could not reduce it except in accordance with the Act of Parliament and in pursuance of the policy of the Legislature. The Act of Parliament prescribed how and under what circumstances the power for reduction arose. The Company were not responsible for that. They did not create it themselves. They could only look to the Act and read there when the case arose, and there could be no doubt that the occasion had arisen in the present instance that the Act of Parliament had prescribed. They were, therefore, in the position of saying, "Now that the case authorising the reduction has arisen, shall we, or shall we not, take advantage of it?" As in the previous trial, he contended that the action, Blisset *v.* Daniel, heard before Vice-Chancellor Wood, and reported at page 493, Vol. X. of "Hare's Reports," had no bearing upon the present suit, adding that when a power was given for the benefit of the whole of a partnership, they could not exercise that power with the object of benefiting a part only. Nothing of the kind in the present case could arise. In the first instance, it was an Act of Parliament which laid down the nature of the conditions under which, and the manner in which, preference and ordinary shareholders should vote. The preference shareholders got their right to vote out of the very clause which made theirs part of the original capital. Everything was regularly fixed by Act of Parliament and by their Articles, and he submitted that the shareholders of the Company had been convened in a proper manner, and had determined to reduce its capital under circumstances when it was quite right that they should do so, unless it could be shown that they had bargained not to reduce it. So far from bargaining that they should not do so, he apprehended that it was part of the bargain that they might do it—having power, no doubt, to place the preference shareholders in a preferential position both as regarded dividend and capital, but giving that preference only as regarded the dividend to the extent that they should have 10 per cent., and leaving them to the operation of the old clause, that their capital "shall be considered as part of the original capital, and shall be subject to the same provisions in all respects as if it had been part of the original capital," and so on. This was no doubt a most important question for preference shareholders in all companies. So far as they knew, in species, the matter was new. Perhaps it was rather extraordinary that it should be so, but there had not been so many cases of reduction of capital as to make it likely to be a common case of law; but every one, he thought, would, by referring both to the Acts of 1867 and 1877, which expressed the matter in perfectly general terms, form the opinion that the action of the Company was perfectly right and justifiable. In the case of Hutton *v.* the Scarboro' Hotel Company it was laid down that if the original Articles of Association did not contain a power, then it could not be exercised—it could not be added by special resolution. All would depend upon the Articles. He went as far as to say that in this case the power that was reserved for an increase of capital was a power which could be increased again and again. It was not exhausted on the first occasion, and an increase of capital could be made from time to time. He thought that was the usual construction of these clauses.

The Court then rose, and the case was adjourned till next week.

INCANDESCENT LAMP MANUFACTURE.

It is well known that legal questions are being fought out with regard to incandescent lamp patents. It is as well known that several meetings have been held by those interested in the manufacture to obtain collective action against what they term monopoly. The following letter from our reporter shows why we have not reported the last meeting. A report of the meeting was forwarded to us, and excellent reasons assigned for the non-admission of reporters, but we cannot break through our rules. The meeting was either public or private; if the latter it cannot concern our readers, if the former we cannot give a report not taken by our own representative.—[Ed. *E.*]

"Sir: I attended the meeting yesterday at the Cannon-street Hotel, convened by Messrs. Woodhouse and Rawson. I was, however, informed that it was a private meeting, but that I could stay if I could guarantee that my report should be seen by them before it was published. Of course, I could give no such guarantee, and stated so. On that I was informed that they had their own shorthand writer present, and that a report of the meeting should be forwarded to you.

"November 9, 1886."

COMPANIES' REPORTS.

West India and Panama Telegraph Company.

Report of the Directors, to be presented at the nineteenth ordinary general meeting of members, to be held at Winchester House, Old Broad-street, E.C., on Wednesday, the 17th November, at 12 o'clock noon:—

The amount to credit of revenue is £45,434. 18s. 7d., and the expenses have been £26,686. 5s. 10d., leaving a balance of £18,748. 12s. 9d., which, with the balance of £4,369. 4s. 3d., brought from last account, makes a total of £23,117. 17s. Of this sum the Directors have placed £7,000 to reserve, leaving an available balance of £16,117. 17s., with which it is proposed to deal as follows:—

	£	s.	d.
Payment of 8s. per share on account of arrears of dividend on the First Preference Shares.........	13,825	4	0
Balance to current half-year's account	2,292	13	0
	£16,117	17	0

The traffic receipts show a decrease of £5,039. 11s. 9d. as compared with the corresponding period of 1885, attributable to the depressed condition of the West Indian trade. The Company's ss. "Grappler" has been engaged in repairing the duplicate Jamaica-Porto Rico section. Owing to the great depth for many miles on each side of the break, which is in 2,400 fathoms, the Board decided, in executing the repairs, to lay the new cable required in much shallower water. After laying in 120 knots of new cable, the "Grappler" was compelled to discontinue operations in order to proceed to the repair of the Jamaica-Colon section, one break in which has been already made good. She is now engaged upon another interruption midway between Jamaica and Colon. A contract has been entered into with W. T. Henley's Telegraph Works Company for the manufacture of 250 knots of deep sea cable to replenish the stock in the West Indies. For the purpose of taking out this cable the ss. "Grappler" will shortly return to London. The Government of British Guiana have not acceded to the Company's proposal for laying a new cable between Demerara and Trinidad. The Board are still in communication with the colony on the subject. The colonies of British Guiana, St. Kitts, Antigua, and Dominica have renewed their subsidies for a further term of one year. With reference to the proposal of Her Majesty's Government to lay a cable between Halifax, Bermuda, and Jamaica, the Directors have satisfaction in announcing that they have been informed by the Secretary of State for the Colonies that, for the present, it has been decided to call for tenders for a cable between Halifax and Bermuda only.

Business Notice.—Mr. J. Slater Lewis informs us that he has transferred his business of telegraph engineer to the Telegraph Manufacturing Company (Limited), of which he himself becomes the managing director. We understand that this company has built extensive works at Helsley, Cheshire, and supplies every description of telegraph apparatus, including instruments, line wires, covered wires, batteries and insulators.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Nov. 10.		Business Done Week Ending Nov. 10. Highest.	Lowest.	
Anglo-American	37½,	38½	39¼	38	
Do. Preferred	60½,	61½	62¼	61	
Do. Deferred	16,	17	17¼	16¾	
Brazilian Submarine	10⅞,	11⅛	11⅛	10⅞	
Cuba	11¼,	11¾	—	—	
Do. Preference	18,	19	—	—	
Direct Spanish	1½,	2	—	—	
Do. Preference	14¼,	14¾	—	—	
Direct United States Cable	9⅜,	9⅝	9⅝	9⅜	xd.
Eastern Telegraph	10⅜,	10⅝	10⅝	10⅜	
Do. 6 per Cent. Preference	14¼,	14¾	14⅜	14¼	
Do. 5 per Cent. Debentures, 1899	105,	108	—	—	
Eastern Extension	11,	11½	11 7-16	10⅞	
German Union	9¼,	9¾	9½	—	
Globe Telegraph and Trust	5⅞,	6⅛	6 1-16	5 15-16	xd.
Do. Preference	12⅝,	12⅞	12 13-16	12 11-16	xd.
Great Northern	13¼,	13½	13⅜	13½	
Indo-European	34½,	35½	34	—	xd.
Reuter's	7¼,	7¾	—	—	
Submarine	195,	205	200	198	
West India and Panama	⅝,	⅞	—	—	
Do. 1st Preference	8¾,	9¼	9⅛	—	
Western Brazilian	6⅝,	6⅞	6 13-16	6⅝	
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—	
Do. 6 per Cent. Sterling Bonds	101,	103	—	—	

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	3-16	5-16	—	—
United Telephone	14⅛,	14⅜	14⅛	14⅛

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2,	2½	—	—
Do. (fully paid)	4¼,	4½	—	—
Swan	1⅜,	1⅝	1⅜	—
Maxim Weston	¼,	⅜	—	—

MISCELLANEOUS.

Telegraph Construction	39	40	39¾	39½
India Rubber, Gutta Percha, and Telegraph Works	24½	25½	25¼	24⅞

TRAFFIC RECEIPTS FOR OCTOBER, 1886.

Companies.	Oct., 1886.	Oct., 1885.	Increase.	Decrease.
Cuba Submarine	2,400	2,156	244	—
Direct Spanish Telegraph	2,013	1,756	257	—
Eastern Extension	37,185	43,986	—	6,801
Eastern Telegraph	49,374	56,994	—	7,620
Great Northern	22,240	—	—	—
West Coast of America	4,285	—	—	—

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NOTES.

TORTOSA, SPAIN.—A company is being formed at Tortosa to light the city by electricity, the motive power being derived from the River Ebro.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended the 12th inst. amounted to £4,140.

ELECTRIC RAILWAYS IN THE STATES.—The following new lines are announced:—At Denison, Texas; at Fairmount Park, Philadelphia; at Port Huron, Mich.

THE WEST INDIAN CABLES.—The cable between Dominica and Martinique is repaired, and telegraphic communication with all the West Indian Islands is therefore restored.

THE BRITISH MUSEUM.—On Tuesday evening, about 6:45 p.m., the electric lighting arrangements at the British Museum suddenly broke down, and the Reading Room had to be closed an hour before the usual time.

LITTLEHAMPTON ELECTRIC TRAMWAY.—This scheme is being actively pushed on, the parliamentary notices and advertisements being now published. Volk's patent central channel system of conducting the current will be used.

EASTERN EXTENSION CABLE COMPANY.—We understand that the "Recorder," belonging to the Eastern Extension Company, has arrived at Thursday Island, and is now engaged in making the cable connection between this island and Cape York.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended Nov. 12 were £3,433, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th inst. are £2,118, as compared with £1,830 in the corresponding period of 1885. The July receipts, estimated at £5,057, realised £5,154.

THE NEW YORK ELECTRIC CLUB.—We have received a copy of the bye-laws of the Electric Club of New York City, which has been formed "to promote social intercourse among those interested in electrical matters, and to provide them with the conveniences of a club house."

THE JUBILEE OF THE TELEGRAPH.—It may not be generally remembered that next year is not only the Royal jubilee, but is also the jubilee of the electric telegraph in England. The first practical electric telegraph was worked between Euston Station and Camden Town on July 25, 1837.

SOCIÉTÉ FRANÇAISE DE PHYSIQUE.—At the meeting of this society, to be held this (Friday) evening, a paper will be read by M. A. Leduc on "Variations of the Magnetic Field Produced by an Electro-magnet," and M. H. Fontaine will read a further paper on his recent experiments on the transmission of force.

NASAL "GALVANO-CAUTERY."—Makers of medical electric appliances will find an article which should interest them in last week's *Lancet*, where Dr. Havilland Hall describes several successful operations for the treatment of sneezing fits, hay-fever, asthma, &c., by electric cautery of the mucus membrane.

EXPORTS OF TELEGRAPH APPARATUS TO SPAIN.—From the *Board of Trade Journal* we learn that during the month of September the export of telegraph wire and apparatus to Spain, under the new commercial treaty with that country, amounted to over £14,000, against only £44 in the corresponding month last year.

THE DIRECT SPANISH TELEGRAPH COMPANY (LIMITED) *ats* BANNATYNE.—The appeal against the decision of Vice-Chancellor Bacon in this action, which was partly reported in *The Electrician* last week, is down for hearing to-day, and we shall be able to give the continuation of the report in next week's issue.

ELECTRICAL SMOKING CONCERT.—The Electrical Engineering Football Club, of 12, Prince's-street, Hanover-square, held their first smoking concert on Wednesday, 17th inst., at the Masons' Hall Tavern, Basinghall-street. Messrs. A. E. Braddell and G. S. Aspinal presided at the piano. The next concert will be held Dec. 7th.

A NEW EXPERIMENT.—We learn from *l'Electricien* that a M. H. Dunville pledges his scientific reputation to the accuracy of the following observation:—If two glasses of water be placed, one upon the north pole of a powerful magnet and the other upon the south pole, in four or five minutes the former acquires a slight alkaline reaction, while that on the south pole becomes slightly acid."

PROPOSED ELECTRIC TRAMWAY AT BRAY, CO. WICKLOW.—Notice is given of intention to apply to the Lord-Lieutenant for an order in Council to authorise the construction, maintenance, and working by electricity or horse-power of a tramway at Bray, Co. Wicklow, about one mile in length. Messrs. Hamilton and Craig, 30, South Frederick-street, Dublin, are the solicitors for the promoters.

THE SOCIETY OF TELEGRAPH-ENGINEERS.—The next meeting of this society will be held at the Institution of Civil Engineers, on Thursday, November 25th, 1886, at 8 p.m., when the discussion on Mr. Gisbert Kapp's paper on "The Predetermination of the Characteristics of Dynamos" will be resumed, and a paper on "Some Experiments on Secondary Cells" will be read by Mr. James Swinburne.

THE ELECTRIC LIGHT ON THE DARDANELLES.—A Central News telegram from Constantinople says:—"The electric light on the heights of Siddul Bahar, at the entrance of the Dardanelles, has been completed, and has given so much satisfaction to the military authorities that further apparatus of a similar kind has been ordered for the other fortresses which command the different bends of the channel up to Nagara."

EDINBURGH INTERNATIONAL EXHIBITION AWARDS.—We are pleased to note that at the above-named Exhibition a gold medal was awarded to Messrs. Laing, Wharton, and Down, as exhibitors of the Thomson-Houston arc lighting system. During several months past a Thomson-Houston incandescent machine has also been run successfully at the Edinburgh Exhibition, but it seems to have attracted very little attention.

PARIS INTERNATIONAL EXHIBITION, 1889.—The first meeting of the recently appointed committee on electro-technics in connection with this Exhibition was held on November 8th. M. Mascart was elected president, and four vice-presidents for the sub-sections were appointed as follows:—Lighting, M. Bartel; experimental work, M. Becquerel; dynamos and motors, M. Maurice Levy; telegraph, telephones, &c., M. Blavier.

THE PHILADELPHIA "CONDUIT" LINE.—The principal difficulty which has hitherto been experienced with the Philadelphia "Conduit" line has arisen from the immense numbers of

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caterpillars which have persisted in making themselves as objectionable as possible, and multitudes have died happy in the consciousness that their mangled remains would reduce the insulation of the circuit. As yet, however, they have not succeeded in actually breaking down the line.

THE MANCHESTER JUBILEE EXHIBITION.—In Section III. of this Exhibition, which is devoted to electro-chemistry, it is intended to exhibit the historical and modern methods adopted in the several branches of the art of electro-metallurgy, such as gold, silver, platinum, nickel, and copper plating, the purification of metals by electrolysis, and generally to illustrate the connection between electricity and chemistry. Application for space should be made not later than the 1st of December.

MANUAL ENGINE FOR DRIVING SMALL DYNAMOS.—Mr. Sellars, of Birkenhead, has devised a manual engine, worked by self releasing grips, and a rope passing over pulleys, with a maximum of friction, by which one man can drive a dynamo with sufficient speed to maintain a couple of 10-candle incandescent lamps. The maker suggests that for the various purposes to which a current of short duration may be applied, this machine will often prove more convenient and economical than the use of batteries.

ELECTRIC LIGHTING OF TRAINS.—The following paragraph appeared in a recent issue of the *Globe*:—"The London, Brighton, and South Coast Railway Company have given an order to the Railway Electrical Contractors (Limited) for a considerable extension of the system of lighting railway carriages by electricity, which has been successfully in operation on the line for some years." The company referred to are the proprietors of the Stroudley-Houghton system for the electric lighting of trains.

THE BARTHOLDI STATUE.—Whatever the merits of the electric light installation by means of which Bartholdi's colossal statue of Liberty is represented as enlightening the World, just outside New York, the absurdity of the erection, as we suspected all along, has not escaped the notice of the American people. A Canadian contemporary, *The Week*, states that the nation that has received the gift treats it with extreme levity, the comic papers transforming the goddess into an indignant wife, with a candle held aloft, receiving her belated spouse.

A BIG FERRANTI.—A correspondent informs us that Messrs. Hick, Hargreaves and Co., of the Soho Ironworks, Bolton, have just built a large dynamo to the order of a London electrical firm. The machine is of the Ferranti type, and is intended for the supply of 5,000 lamps, apparently 16 candle-power each. The armature is 9ft. in diameter; the weight of the field-magnets and frame is about 20 tons. The same firm are supplying a Cortiss horizontal engine of 500 horse-power, from which it is intended to drive the dynamo by rope gearing.

THE DISTRIBUTION OF ELECTRICITY.—The following paragraph appears in several of the American journals:—"Mr. G. Westinghouse (the inventor of the Westinghouse air brake) has taken out a patent for a new method of distributing electricity for lighting and other purposes, which, it is said, will cheapen the cost of lighting very much, and enable the electric light to compete much more successfully with gas. It is said to effect a saving of 95 per cent. as compared with Edison's system. A test with a main circuit wire of less than a quarter of an inch in diameter carried the current for 850 sixteen candle-power lights a distance of three miles."

THE SILVERTOWN COMPANY.—The cable steamer, "International," arrived at the moorings off the Silvertown Works, on Wednesday, the 17th inst., on her return from repairing and in part renewing one of the Havanah Key West cables. On account of the depth of water, and the strong currents running along the North Coast of Cuba, considerable difficulty has been experienced in effecting this repair, which has been successfully completed by Theophilus Smith, Mr. March Webb being chief electrician. Mr. Smith has been greatly aided by the local knowledge of Mr. M. Hellings, the cable manager of the International Ocean Telegraph Company.

THE LIVERPOOL ELECTRIC SUPPLY COMPANY.—The *employés* of this firm had on Saturday an excursion to Chester, which included dinner and tea at the Queen's Head Hotel. The project originated with the men employed in connection with the lighting at the "Shipperies," which had been so successfully carried out by the company. A very pleasant day was spent, and the health of the managing directors, Messrs. Holmes and Vaudray, was drunk with enthusiasm. Under the superintendence of these two gentlemen the Liverpool Electric Supply Company has carried out a large amount of excellent work in Liverpool and the neighbourhood during the five years of its existence.

ECONOMY OF ELECTRIC LIGHTING IN MINES.—Speaking at the recent meeting of the Montana Company, Mr. John Bayliss said, referring to the introduction of the electric light, that the total cost of the installation had been $3,665, and that the cost per month for working, including maintenance and interest on the capital, was $250. The old system of lighting cost $500 a month, so there has been a saving on this item of $3,000 a year on an expenditure of $3,365. Beyond that there was the untold saving arising from the comparative immunity from fire by the electric light, compared with the position under the old system of oil and candles. It was intended to extend the installation to the new 60-stamp mill, but the cost would not exceed $1,200.

SPANISH TENDERS.—The Madrid *Gazette* announces that on the 4th of December next tenders will be received at the office of the Director-General of Posts and Telegraphs, and simultaneously at the telegraph offices of Victoria, Burgos, Palencia, and Soría, for the supply of 7,000 posts for the service of the State telegraphs, viz., 2,000 of a length of 6 metres, 4,000 of 7 metres, and 1,000 of 8 metres. The maximum prices fixed by the authorities are 8, 9, and 10 pesetas each respectively. Tenders are also invited on the 11th December, at the central offices of the Post and Telegraph Department, Madrid, and simultaneously at Lerida, Gerona, Barcelona, and Tarragona, for 2,900 telegraph posts, viz., 2,600 of 6 metres at a maximum price of 8 pesetas each, and 300 of 8 metres at a maximum price of 10 pesetas.

THE BRIGHTON ELECTRIC RAILWAY.—This line is now repaired. Owing to the withdrawal of the shingle on which the line was placed a viaduct about 480ft. long has been built to carry the line. The work occupied three weeks, during which time the cars ran only between the Chain Pier and Kemp Town. On Saturday last the Lord Mayor of London (Colonel Sir Reginald Hanson), Mr. G. H. Puleston, M.P. for Devonport, and a numerous party, visited the line and inspected the various arrangements for working it. The party also took a double journey on the cars, and seemed most pleased with the arrangements. A short time ago Lord Augustus Loftus, the late Governor-General of New South Wales, visited and inspected the undertaking with a view to its introduction into Australia.

"ENCORE CREIL."—If any of our readers still retain any interest in the discussion of the results of M. Deprez's experi-

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ments at Creil, we commend them to the current number of the *Revue International de l'Electricité*, which contains an article entitled, "La Vérité sur les expériences de Creil Entraits du rapport de M. Maurice Lévy, *modifié* par E. Boislet," The *modifications* are effected by the insertion in the body of the original report of numerous words, sentences, and paragraphs which are distinguished by being printed in italics. The alterations are in general such as to flatly contradict the assertions of the original; they are inserted with considerab'e literary skill, and the result is a very lively paper of some eight or ten pages in length. However, we have already had our say in the matter, and do not see the necessity for pegging away at the subject in the way that the French press does.

Telegraph Clerks and the Civil Service Commission. On Saturday evening a large meeting of telegraph clerks was held in Edinburgh to consider what steps should be adopted to obtain the necessary information and evidence to appoint witnesses to attend the meetings of the Royal Commission of Inquiry. Much satisfaction was expressed that the department had been selected on its merits as one of those branches of the civil service which was entitled to be inquired into. The fact that it has been included along with other departments showed that it had at last been recognised as one of great importance, and there was no doubt that in the course of investigation facts would be elicited proving that the telegraph department was second to none of the minor branches. A resolution to this effect was passed, and a vote of thanks awarded to Mr. Puleston, M.P., who has been mainly instrumental in bringing this matter to its present issue.

Contich, Belgium.—A correspondent sends us the following interesting account of a forthcoming Belgian central lighting station. The municipality of Contich is about to grant a concession to the *Société d'exploitation de force motrice and d'éclairage* for a town installation. The streets will be lit with arc lamps, and up to the present time private installations to the extent of about 300 incandescents have been arranged. Two installations for the transmission of force have also been contracted for, one of 12 and the other of 300 horse-power. The financial arrangements are as follows:—Incandescent lamps, 4 centimes per lamp-hour from 8 to 10 candles, 7 centimes per lamp-hour from 16 to 20 candles, 12 centimes per lamp-hour from 40 to 50 candles. Arc lamps, 40 centimes per lamp from 500 to 1,500 candles, 50 to 55 centimes from 1,700 to 2,000 candles. The charges payable upon first installation are as follows:—20 francs per lamp for an installation of 1 to 5 lamps, 18 francs per lamp of 6 to 25 lamps, 16 francs per lamp of 26 to 50 lamps, 13 francs per lamp of 51 to 100 lamps.

Recent Work of the E.P.S. Company.—The Electric Power Storage Company have just completed a successful installation of private house lighting at Colonel Stebb's residence at Scarborough. The plant consists of a 7-unit Elwell-Parker dynamo, supplying current to 33 cells of the 31 L type, and driven by a 7 horse-power gas engine. The main distributing switch-board is fitted with Drake and Gorham's patent measuring instruments and ring contact switches, and the whole arrangement of the installation was rendered by these gentlemen—who designed the work throughout—so simple in its working that, although it has been left in charge of a local man with no previous knowledge of electricity, no trouble in its manipulation has occurred. An equally successful installation has just been completed by the same company at the offices of the North British and Mercantile Insurance Company, which are now lit throughout by means of 160 incandescent lamps, supplied from a 9 unit dynamo and 53 E.P.S. cells. The power is derived from a 9 horse-power Otto gas engine placed in the basement of the building.

"The Revolution in Electrics."—Under this title the *Liverpool Courier* has an article commencing as follows:—"Since the appearance in this paper of the article on the above subject—the first announcement to the world of this new system—Mr. Quarrie, of Ulverston, reports that he meets a sullen opposition from so-called 'practical electricians,' all of which may go to delay his plans, but which will also emphasise in the manner it deserves the contemptibleness of the little-minded beings who have so tried to keep back simple truth. Electricians may cough, or cavil, or snap, or sneeze at this just as it may suit their various constitutions, but that the thing is workable, cheap, simple, endurable, and an overwhelming improvement and saving, they cannot gainsay; and more, they will not have long to wait to see it at work, which after all is the best argument." As an exponent of the views of "practical electricians," we need hardly say that, after our comments of last week, we await the outcome of Mr. Quarrie's experiments in fear and trembling, lest we should have to eat our words and hide our diminished heads.

Overhead Wires.—The *Lancet* of November 13th contains the following paragraph:—"The 'Works and General Purposes Committee' of the Metropolitan Board of Works has been good enough to agree with a Select Committee of the House of Commons in the opinion that something should be done about the overhead wires of the telegraph and telephone systems. This is encouraging, and ought to prove consoling to the surviving victims of accidents, and the friends of sufferers generally, during the long period which is only too certain to elapse before any serious step is taken in the matter. From a practical political point of view, we must confess that this accord between two 'authorities' in condemning an easily remediable evil does not appear likely to expedite a much-needed reform. Being agreed on the subject, the authorities concerned will probably shelve the question at issue. It is, then, necessary that the agitation commenced in the interest of public safety should be promoted with increased vigour. Doubtless there will be plenty of illustrative narratives of fact available for the purpose of argument as soon as the winter snows make their appearance."

Launch of a Cable Ship.—On November 12th there was launched from the yard of Robert Thompson and Sons, Southwick, Sunderland, an iron screw steamer, designed for the laying down and picking up of submarine cables, built to the order of Messrs. Pirelli and Co., Milan, Italy. As the vessel left the ways she was gracefully christened the "Citta di Milani" by Mrs. Pirelli, wife of one of the owners. The dimensions of the vessel are as follow:—Length, as per Board of Trade, 240ft.. breadth 32·2ft., depth of hold 24ft., and she is fitted up with three tanks for holding cables, besides having the usual appliances of merchant ships. On the main deck there will be fitted a combined "picking up and paying out machine," by Messrs. Johnson and Phillips, London, driven by a pair of powerful independent engines; also on this deck are the saloon, cabins for officers, engineers, electricians, and cable hands. The saloon is neatly arranged, and fitted up in mahogany, rosewood, and maple, electro-plate fittings, electric light throughout, pneumatic bells, &c. At the bow and stern of the vessel are the sheaves and whiskers through which the cables are passed. The lifeboats are fitted with Sample and Ward's patent disengaging gear, and also patent sheaves for paying out and taking in cables. The engines for the vessel have been built by Mr. George Clark, Southwick, and are

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200 nominal horse-power. The vessel being built on very fine lines, a high rate of speed is expected to be attained.

West African Cables.—The cable steamer "Silvertown" arrived in the Victoria Docks on Sunday, the 14th inst., after an absence of about four months and a half. During this period she has laid six cables on the West African Coast with landing places at Grand Bassam, Accra, Kotoonou or Porto Novo, at Principe Sao Thomé, Gaboon, and at St. Paul de Loanda. This vessel left London on the 3rd July, and returned, after steaming 12,000 miles and being absent four and a half months, without consuming the whole of the coal she took on board at Silvertown before starting on her voyage. The total length of cable laid by the "Silvertown" and her consort, the "Dacia," during this period amounts to some 2,200 nautical miles, and, considering the climate and the landing of twelve shore ends through a West African surf, the staff of the Silvertown Company are to be congratulated on the successful termination of a difficult job. The operations were under the control of Mr. Matthew Hamilton Gray, the director of the expedition, assisted by Mr. H. Benest, chief telegraph engineer, Mr. N. S. Thomson, commanding the "Silvertown," Mr. J. Rymer Jones, chief electrician, Mr. W. S. Seaton, assistant to director, Mr. W. A. Tindall, commanding the "Dacia," Mr. G. Stoddart, superintendent engineer, Mr. D. Wilson Barker, commanding the "Buccaneer," and a staff of about 300 officers and men. Mr. R. E. Peake, assisted by Mr. Bent, represented Messrs. Clark, Forde and Taylor, the engineers to the West African Telegraph Company during the operations.

Callender and Webber's Underground Cable Conduits.—We have recently had an opportunity of inspecting the system of underground cable conduits which has been devised by Messrs. Callender and Webber. A section of some hundred yards was laid down nearly twelve months ago at the Borough-road Works of the Anglo-American Brush Company, where we understand that it will shortly be open to the inspection of all who are interested. Some time ago the opinions of electricians were divided upon the question of metallic or non-metallic conduits; but of late the tendency has been to give a decided preference to the latter type, especially for cables conveying any large number of watts, whether as heavy current or as high electromotive force. An ideal underground system for the distribution of electricity must secure the adequate protection of the cables when laid, provide easy and rapid means of repair, and in the majority of cases foresee future extensions and furnish means for increasing the number of conductors without fresh excavations or reopening the roadways. It is claimed that Messrs. Callender and Webber's system fulfils each of these requirements in a very high degree. The material employed is a natural bitumen, a substance possessing very considerable mechanical strength, together with a remarkably low temperature coefficient and a high insulation. It is impervious to water, and is unaffected either by gases or acids found in the soil. It can easily be bent to any required shape. The conduits are constructed in lengths convenient for handling, and we are informed that the work of jointing is very easily carried out by the application of heat; a collar of the same material is afterwards passed over, making the joint as good as any other part. The conduits are supplied with any required number of channels; and iron boxes for drawing in the wires are placed at suitable intervals. We may add, in conclusion, that the price of the material is not high, and from the well-known durability of genuine bitumen the cost of maintenance ought to be very small indeed.

Duplex Telephony.—With reference to the article upon duplex telephony which appeared in our columns last week, Dr. A. M. Roseburgh, of Toronto, writes to the American journals as follows:—"As attention has recently been called to duplex telephony, I desire to place on record what I have accomplished in this direction. I commenced experimenting over two years ago on the wires of the Bell Telephone Company of Canada, between Toronto and Hamilton, a distance of forty miles, the wires being placed at my disposal for the purpose by Mr. C. F. Sise, the general manager. My object was to utilise the metallic circuit system, so that either two subscribers or a subscriber and a central office operator at each end of a metallic circuit might be able to communicate simultaneously without interference. Through these and other experiments I was enabled to develop a duplex telephone system. I saw that the only solution of that problem was to generate the electrical impulse in both wires simultaneously and in opposite direction. After much experimenting I found that this could be done in several ways, as for instance, first, by using a transmitter with a double-wound secondary coil—one coil for each branch of the metallic circuit; secondly, using a transmitter with two induction coils, the primaries being connected either in series or in multiple arc; and, thirdly, by using what I call a "duplex repeater"—that is, a repeater with two coils, one in each branch of the metallic circuit. In using the duplex repeater the repeating circuit may be cut, one end grounded at the central office and the other end taken to the switch-board for the use of subscribers. By this arrangement two subscribers at each end of the metallic circuit may use the metallic circuit simultaneously, one using the "duplex repeater" and the other the ground wire. In the one case the currents traverse the two branches of the metallic in opposite directions; in the other case, the currents pass the two wires in the same direction, simply using the two wires as a double conductor. It is not difficult to render the central office receivers neutral to the currents for the subscribers' transmitters. A simple method is to wind the electro-magnet double, and insert one coil in one branch and the other coil in the other branch of the metallic circuit. I thus found that by charging the two branches of the metallic circuit simultaneously, and by using differentially wound receivers in the metallic circuit, the ordinary transmitters and receivers could be used in the subscribers' lines. This scheme has the obvious advantages of (1) rendering duplex telephony practicable, (2) facilitating long distance telephony, (3) eliminating induction."

Electric Lighting and Fire Insurance in America. By a somewhat singular coincidence, the views and policy which we advocated in our leader of last week on the question of fire insurance received strong corroboration in the course of a debate which took place a few days previously at the New York Electric Club. On this occasion, Dr. G. H. Benjamin spoke as follows:—"In 1882 the Board of Fire Underwriters of the City of New York adopted a series of rules relative to the precautions to be observed in the introduction of the electric light into buildings, which were published at the time, and with which you are all doubtless familiar. However well these rules may have been suited to the date of their promulgation, I believe it will be generally admitted that they are unsuited and inadequate to the present needs. With all new industries, or the practice of new arts, it has been the rule to allow the utmost latitude, and to impose as few requirements as is possible compatible with public welfare; this with the idea of lending encouragement and facilitating the introduction of such new art or industry; but when after a time the

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industry or art has become well understood and established on a firm commercial basis, further and supplemental restrictions are generally imposed with the intention of making the employment of such art or industry absolutely safe for all concerned, those engaged in the practice thereof as well as those using or being benefited thereby." Dr. Benjamin then referred at some length to what he termed the reckless practice of certain of the American companies, who employ high tension currents, without proper precautions for the safety of their line-men. Coming to the question of fire risks, he proceeded:—"So far as the risks from fire are concerned, it is not necessary to enumerate them. Unfortunately, sad experience has made them only too well understood. Careless, stupid, and one may say criminally loose methods of wiring have been the rule rather than the exception in this country—of course, with some notable exceptions—and all those who have carefully studied the subject and are conversant with the needs feel that the enforcement of proper and stringent rules will not only allay public fears and restore confidence, but likewise materially benefit the industry. I contend, gentlemen, that we should look upon this subject in a broad light and free from the narrow prejudice of business. We should recognise the necessity, and not attempt to evade the responsibility. To make an electric plant perfectly safe may necessitate slightly increased cost of construction, although personally I am inclined to doubt the fact. But even admitting such to be the case, the perfect immunity from danger, the decreased cost of insurance, and the general confidence engendered in the public mind will be a good interest upon such additional outlay."

The Effect of Stress and Strain on the Electrical Resistance of Hard Carbon.—On this subject Mr. Herbert Tomlinson communicates the following note to the November number of the *Phil. Mag.*:—"Prof. T. C. Mendenhall has published in the September number of *Silliman's American Journal* an account of some experiments on the effect of pressure on the electrical resistance of carbon. These experiments deal not only with such comparatively hard rods of carbon as are used in the arc lamp, but also with the compressed lampblack seen in Edison's discs. I will first refer to the experiments on the hard carbon. Prof. Mendenhall seems to think that these are in accordance with some experiments made by myself; but this I rather doubt, for the change of resistance produced by pressure on the carbon rod used by him would appear to be considerably greater than any which was obtained by myself on carbon rods of a similar kind. Had I not employed a very sensitive arrangement for testing small changes of electrical resistance, one which in fact enabled me not only to detect but to measure a change of resistance of about 1 in 100,000, I might have failed in detecting any change whatever. The result arrived at by myself was that a pressure of 1 grm. per square centim. would produce a percentage decrease of only ·00000064. So that, if we assume the decrease of resistance to be proportional to the pressure, there would be required a pressure of 22,215lb. on the square inch to produce a decrease of resistance of 1 per cent. There is reason to believe that the pressure which would suffice to crush carbon is somewhere about 5,000lb. per square inch. If this result be at all correct, it would follow that pressure on the point of crushing the carbon would diminish the electrical resistance by less than ½ per cent. Prof. Mendenhall does not give any data by which the amount of change of resistance observed by him can be calculated; but, if one may judge from the tenour of his remarks and his arrangement for experimenting, it would seem probable that the ratio of change of resistance to pressure was considerably greater in his experiments than in mine. Further, Prof. Mendenhall seems to credit me with doing what I have not done; for, after describing his own experiments on the effect of pressure exerted in the same direction as the current, he goes on to say, 'It was also found that compression at right angles to the direction of the current produced a similar effect, but less in magnitude. These facts had been already announced by Mr. Tomlinson.' I have made no experiments on the effect of compression at right angles to the direction of the current, but I think it probable that if I had I should have found increase of resistance, and not decrease, to follow on compression exerted in the above direction. On the whole, then, I am of opinion that my experiments are more in accordance with those of Professors Sylvanus Thompson, W. F. Barrett, and others, than with those of Prof. Mendenhall."

The Effect of Stress and Strain on the Electrical Resistance of Soft Carbon.—Mr. Tomlinson continues the above cited note as follows:—"As regards soft carbon, such as is used with Edison's discs, I cannot speak from experience. I was, however, much interested in reading the account given by Prof. Mendenhall of his investigations on the subject, and especially with that part of the account which relates to the influence of time on the change of resistance of the carbon disc when the pressure is varied; inasmuch as some of my own experiments have shown a similar influence of time on the electrical resistance of the viscous metals zinc and tin in the form of foil, when traction was applied in a direction transverse to that of the current. At the same time I would venture to suggest to Prof. Mendenhall that his ingenious experiments may not be quite conclusive as to a considerable change taking place in the specific resistance of the carbon. After showing that very considerable change does take place somewhere in the circuit of the mercury in contact with the carbon button and the button itself, he substitutes for the soft carbon a disc of hard carbon similar in dimensions, and finds that a pressure of only 7 centimetres of mercury lowers the resistance by nearly 3 per cent.; and he says, 'There can be little doubt that this small reduction is due almost entirely to better surface contact produced by pressure.' From the above it is evident that the surface contact between the mercury and hard carbon was by no means good; but, writes Prof. Mendenhall, 'The faces of a soft carbon disc are always smooth and polished; the surface of hard carbon, on the contrary, is generally more or less rough and irregular. It would appear, therefore, that if the reduction of the resistance of soft carbon by increase of pressure is due to better surface contact, this reduction of resistance should be much more marked with hard than with soft carbon.' The above assumption is a very dangerous one to make, for the surface of the soft carbon might not be in the same state of cleanliness as that of the hard carbon. But even suppose we allow that there was better contact with the mercury in the case of the soft carbon than in that of the hard carbon, it does not necessarily follow that the observed decrease of resistance consequent on increase of pressure occurred in the carbon of the button. The buttons are, I believe, formed by compressing lampblack mixed with gum-water. Must we not suppose, then, that the particles of lampblack are bound to each other by the gum, and separated from each other by the gum, to a greater or less extent? Would not the diminution of resistance experienced in the body of the button when pressure was applied be due to one or both of the two following causes:—(1) Diminution of the resistance of the thin coating of gum between the particles of carbon; (2) Better surface contact between one particle of carbon and another? The influence of time on the change of resistance might be quite accounted for by supposing cause (1) to be at work."

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 8.)

The attraction which a magnet exerts upon a piece of soft iron is explained in a manner similar to the attraction of an electrified body upon an unelectrified conductor. If a piece of iron be held near the north pole of a magnet it becomes magnetised by induction, a south pole being induced near to the magnet and an equal north pole at the remote end, but the south pole being nearer to the pole of the magnet than the north pole of the iron, the attraction will exceed the repulsion, and the iron will be drawn towards the pole of the magnet.

Def. A line of magnetic force is a line which at every point is in the direction of the resultant magnetic force at that point.

If a card be placed in a horizontal position above a magnetic pole, or a number of magnetic poles, and if iron filings be sprinkled on the card and the card gently tapped to enable the magnetic forces to overcome friction, the iron filings will arrange themselves in lines, which are at every point in the direction of the resultant magnetic force at that point. This is explained as follows:—

Suppose the horizontal lines in Fig. 5 to represent lines of magnetic force, and that the particles of iron are spherical.

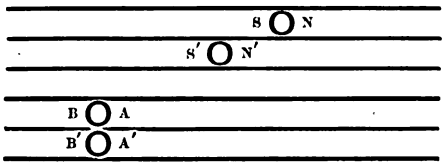

Fig. 5.

They will then become magnetised by induction in the direction of the lines of force. Now, consider the two particles S N, S′ N′. The attraction of the poles S and N′ will, notwithstanding the action of the other poles, cause the particles to move together, and link themselves to one another, forming the commencement of a thread in the direction of the lines of force. On the other hand, the particles A B, A′ B′, which are exactly side by side, will repel one another, so that there will be a tendency for the particles to form threads along the lines of force, and for these threads to repel one another so as to leave clear spaces of considerable extent between them. If the particles are not spherical, but elongated, there will be a tendency for them to become magnetised in the direction of their greatest elongation; but the particles will tend to set with their greatest lengths along the lines of force, and they will then act on one another like the spherical particles, but more strongly.

It will frequently be noticed that the region of the card just above the magnetic poles becomes completely bare of filings. This is due to the magnetic force being perpendicular, or nearly perpendicular, to the card. The filings then become magnetised vertically, and neighbouring filings repel one another until they have driven each other away from the poles. If the card is thin and the magnet very strong a great mass of filings may be held over the pole, the filings being built up into vertical threads.

If a cylindrical bar magnet be placed with one pole touching the card upon which the filings are sprinkled, and the axis of the magnet at right angles to the card, the filings will exhibit the lines of force due to a single pole, and will radiate uniformly in straight lines from the pole.

If two dissimilar magnetic poles be placed upon the card, the lines radiating from one pole will have a tendency to turn round and converge towards the other pole; and if the poles are of equal strength, and there are no other magnets in the neighbourhood, almost all the lines of force from one pole will sooner or later reach the other. (Figs. 1 and 2)

If two equal and similar poles are placed near together, the lines of force from each will, apparently, repel those from the other; and if a line be drawn, bisecting at right angles the line joining the two equal poles, all the lines of force will be turned aside so that none of them will cross this line. (Fig. 3.)

If a piece of iron (nickel, cobalt, or any other substance whose magnetic permeability is greater than that of air) be introduced into a magnetic field, the lines of force will be drawn aside so that as many as possible may pass through the piece of iron. (Fig. 4.) If a piece of iron be placed very near to one end of a bar magnet, most of the lines of force from that pole will pass straight from the end of the bar to the piece of iron. If the iron be removed, more of the lines of force will pass radially from the sides of the bar. This alteration in the magnetic field takes place in a telephone as the iron disc vibrates.

In dynamos and magneto-electric machines iron cores are frequently employed in order to draw the magnetic lines of force through the coils of the armature, instead of allowing them to be more uniformly distributed through the surrounding space. When the "keeper" is placed upon a magnet nearly all the lines of force of the magnet pass from the north pole to the south pole through the keeper, and very few pass through the surrounding air. Hence a magnet with its keeper attached has very little action upon any other magnets or magnetic bodies in its neighbourhood.

From the law of magnetic action stated above it follows that the force between two magnetic poles will be represented by the product of the strength of the poles divided by the square of the distance between them if the unit magnetic pole be properly selected.

Def. The unit magnetic pole is that north magnetic pole which acting *through air* upon an equal magnetic pole at a distance of one centimetre repels it with force of one dyne.

This is analogous to the definition of the unit of electricity, and the words *through air* are introduced for the same reason as in that definition. If a piece of brass, copper, wood, &c., be introduced between the magnetic poles the repulsion (or attraction) will not be sensibly affected, for the magnetic inductive capacity (analogous to specific inductive capacity in electricity), or, as it is more generally called, the magnetic permeability, of these bodies is sensibly the same as that of air. If, however, a piece of iron, nickel, or cobalt be introduced between the magnetic poles the effect will be very different, the magnetic permeability of these substances being much greater that that of air. If a magnet be completely surrounded by a soft iron case it will be protected from the influence of all magnets outside the case. These phenomena are best explained by help of the conception of magnetic lines of force. For example, when a body is surrounded by a soft iron case any lines of force tending to pass from one side of the case to the other will pass through the substance of the iron without reaching the enclosed body, which will thus be effectually protected from the action of the force. Iron watch cases prevent the hair springs being magnetised by dynamos, and iron cases to galvanometers cut off the action of the earth and of external magnets from the instrument.

The law of magnetic action above stated may be verified by means of Coulomb's torsion balance. For this purpose a bar magnet is suspended from the torsion head and a second magnet is introduced into the case so as to repel one pole of the suspended bar. The torsion head is turned until the suspended magnet rests in a definite position, and the distance between the repelling poles is measured and the torsion of the wire observed. On repeating the experiment with different distances between the repelling poles, and different amounts of torsion in the wire, it will be found that the repulsion between the poles, measured by the torsion of the wire (with the necessary corrections introduced) is inversely proportional to the square of the distance between the poles.

A second method consists in causing a small magnetic needle to vibrate at different distances from one pole of a very long vertical magnet. The square of the number of vibrations executed in a minute is, in this case, proportional to the force acting on one pole of the magnet. In this experiment allowance must be made for the action of the earth by swinging the little needle under the action of the earth alone, then introducing the long magnet, placing its pole at different distances from the needle, but in such a position that the force exerted on each pole of the needle by the large magnet is in the same straight line as that exerted by the earth

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Def. The moment of a magnet is the product of the strength of either pole and the distance between the two poles.

The effect of a magnet upon other magnets or magnetic bodies at a considerable distance depends upon the moment of the magnet. If a bar magnet be bent into the form of a horseshoe its magnetic moment will diminish as its poles are made to approach each other, and if the bending be continued until the poles are in contact and a complete ring is formed, the magnetic moment will be reduced to zero, and the magnetised ring will exert no action at any point outside its own substance.

Def. The magnetic potential at a point is the number of units of work which must be done on a unit (north) magnetic pole to bring it from an infinite distance to the point.

Def. The magnetic moment of a magnet divided by its volume is called the *intensity* of magnetisation of the magnet.

If the intensity is not the same throughout we must take the magnetic moment of a small portion of the magnet, and divide by the volume of that portion, in order to obtain the intensity of magnetisation of the portion considered. If a uniform bar be not uniformly magnetised it will exhibit polarity wherever there is a change in the intensity of its magnetisation. If the intensity diminish continuously from the centre towards each end, there will be a north pole spread over the whole of the surface of one half of the magnet, and a south pole occupying the surface of the other half. If the intensity of magnetisation of a uniform bar were uniform throughout its whole substance, the poles would appear only at the ends of the bar. As stated above, it is impossible to realise this condition in actual magnets, and consequently the poles, instead of being concentrated at the ends, are spread over a considerable portion of the magnet in the neighbourhood of its ends. (See Fig. 1.) If a uniform bar were uniformly magnetised, the intensity of magnetisation would be numerically equal to the strength of the pole formed by a unit of area of the plane end of the magnet.

Though a bar is so magnetised that it has no true poles, its north and south polarity being each distributed over a considerable area of its surface, it nevertheless possesses a definite magnetic moment. For such a bar may be supposed to be cut into very fine threads, each of which will possess equal amounts of north and south magnetism at its ends, and these being practically points its magnetic moment will be the product of the strength of one pole into the distance between the two. The sum of the magnetic moments of all the threads will be that of the bar. It should be noticed that the threads will generally be curved and thinner near the ends if the bar be straight and of uniform section. But the simplest method of defining the magnetic moment of such a magnet as we are considering, whose poles cannot be defined, is to say that its magnetic moment is numerically equal to the couple which would be exerted upon it if placed in a uniform magnetic field of unit strength, with its magnetic axis at right angles to the direction of the magnetic force—that is, when placed at right angles to the direction which it assumes when perfectly free to move.

The behaviour of magnets upon one another, and upon magnetic substances like soft iron, is consistent with the hypothesis that magnetic action consists of a stress in a medium filling space; that there is a tension along the lines of magnetic force, and an equal pressure at right angles to them. The tension along the lines joining opposite poles explains the attraction which they appear to exert upon one another. The pressure in every direction at right angles to these lines explains the apparent repulsion between similar poles, the lines of force from which are diverted, and proceed side by side so as to exert, as it were, a pressure upon one another. If a piece of soft iron be placed near to a pole of a magnet, the lines of force from the pole will converge upon the iron, and thus between the pole and the iron the lines of force will diverge less than before, while as soon as they have passed through the iron they will diverge more than before. The tension along the lines will therefore act upon the iron in much the same way as a number of stretched elastic strings would act upon a smooth ring if the strings were radiating from a point and attached to the walls of the room, and the ring were placed upon them so as to draw several of them together. Such a ring would be pushed towards the point from which the strings diverged, and in a piece of iron in a magnetic field of variable intensity will be pushed towards the point from which the lines of force diverge—that is, towards the strongest part of the field, or to the pole of the magnet from which the lines of force originate. (See Fig. 4.)

Previous to 1845 it had been observed that bismuth and antimony if placed near the pole of a powerful magnet were repelled. In that year Faraday took up the subject and found that all the bodies upon which he experimented were affected more or less by the pole of a magnet, and that while many bodies, like iron, were attracted by a magnet or tended to move to the strongest part of the magnetic field, by far the greater number of bodies were repelled by a magnet or tended to move towards the weakest part of the magnetic field. Bodies which are acted upon in the same way as iron are called *magnetic* or, sometimes, *paramagnetic* substances. Those which behave like bismuth and antimony are called *diamagnetic.*

(To be continued.)

TESTING DYNAMO MACHINES.

BY JAS. SWINBURNE.

(Continued from page 10.)

THE TESTS.

As the first example of efficiency tests, that of two similar series wound machines may be taken. We will suppose them arc light machines of high electromotive force. The motor and generator have their pulleys connected by a belt, and the machines are coupled up electrically in series with a small machine, D. If the small machine is run, it will send a current

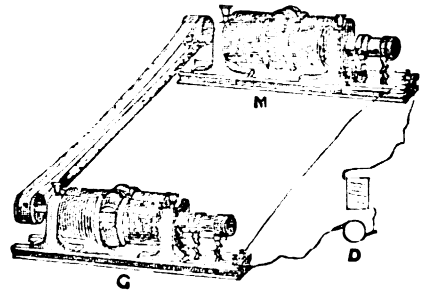

FIG. 1.

through the other two; but they will not start, as the torque will be the same in the two similar machines. This difficulty may be got over in several ways. Thus, the motor may have a smaller pulley than the dynamo. The size of the pulleys should be arranged so that the small one is to the large as the expected efficiency of conversion of the two machines is to 100—that is to say, the difference should be enough to allow for the loss of power due to Foucault currents in the armature, to magnetism, and to mechanical friction and belt slip. If the pulleys are not the right sizes, either the current will come wrong or the machines will not run at their normal speed. Let us suppose that the pulleys are chosen correctly, and that one of the machines, say the generator G, is to be tested. We will take its working conditions to be 2,000 volts, and 10 amperes at 900 revs. The small dynamo D is run up till it gives 10 amperes. The large machines will run quicker and quicker till the product of their torques and speeds is equal, or only differs enough to allow for belt slip; this will be at their normal speed if the pulleys have been correctly chosen.

We will assume hypothetical readings and work them out; G gives 2,000 terminal volts, the loss in the armature calculated from the hot resistance is 120 volts with 10 amperes, and in the field 120 volts. We will suppose the current to be quite steady; then, using Prof. Thompson's lettering for the sake of uniformity, the terminal electromotive force $e = 2{,}000$, on the brushes it is $\epsilon = 2{,}120$, and $\mathfrak{E}$ the armature

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electromotive force is 2,240 volts. The motor M is $e=2{,}721$ and $\epsilon=2{,}601$, $E=2{,}481$. We have therefore $2{,}481-2{,}240=241$ volts spent in other ways than in overcoming the resistance of the wire of the machine, and the problem is to divide this loss fairly between the two machines. The losses in power, due to different causes, vary differently with the speed. For instance, the power lost by Foucault currents varies nearly as the square of the speed, while the loss from persistent magnetism is probably as the speed. It is most likely the best way to distribute the loss as the square of the speeds. In choosing the hypothetical readings the efficiency of conversion was taken at 95 per cent., so that G ran at 900 and M at 1,000 if there was no belt slip. Then the 241 volts, or 2,410 watts, will be distributed, M 1,330 and G 1,072. The armature of G gives 22,400 watts, so that the whole power given to G is 23,472 watts. In the same way the motor has $e=2{,}721$, $\epsilon=2{,}601$, $\mathfrak{E}=2{,}481$, so, as 130 watts are lost it transmits 23,480 watts. The eight extra is here due to the use of the slide rule. This supposes that there is no belt slip, but take the belt slip = 1 per cent. as the reading obtained by comparing the observed and calculated speeds of the dynamo shafts. A belt slip of 1 per cent. is 235 watts, and this power is part of the 2,410 watts not accounted for by the electrical resistance of the machine. This leaves 2,175 watts to be divided between the two machines. That gives M 1,211 watts and G 962 watts. The reason why the motor and generator were taken as similar machines in the example is that it is the only way this particular loss can be accurately determined. If the machines were not alike, it would be easy enough to determine the efficiency of the two machines taken together, but the loss in one alone could not be so well separated. We have found that the generator G receives 23,362 watts, which is spent as follows:—

	Watts.
Loss in armature by resistance	1,200
„ „ in field-magnets	1,200
„ „ mechanical friction, Foucault currents, persistent magnetism, &c., in the armature ...	962
Total loss in the machine	3,362

Efficiency, 84·6 per cent.

If the current is not steady, some precaution becomes necessary. The main current must not be measured with an ordinary ammeter, but an electro-dynamometer must be used. Such an instrument does not really indicate the current, but gives what may be called the virtual current, which, when multiplied by the virtual electromotive force, taken with an electro dynamometer voltmeter, without self-induction, gives real power spent in any part of the circuit that is resistance only—that is, has no electromotive force, induced or otherwise produced. Again, if the current is variable, the loss in the fields is greater. To get the loss in the fields, an electro-dynamometer, without self-induction, must be set to measure the power. It will not do to measure even the virtual volts and amperes with two separate instruments and multiply them together, for there is an electromotive force induced in the field coils when the current varies. This method cannot be applied to the armature, so the additional loss due to the variation of currents must be put in with the power unaccounted for by the resistance of the machine. It is probable that two machines, each of which alone gives a varying current, would, when coupled together and run at slightly different speeds, give an approximately uniform current. Instead of electrodynamometers, electrometers may be used. Enough has now been said to show the great advantages of this method of testing machines. The whole of the tests are taken without any mechanical dynamometers, and even the instruments need not be correct. It is a common practice among electrical engineers to measure resistances in B. A. ohms, and E.M.F. in what would be "legal" volts if they were a good enough shot to be anything at all; but all that is demanded with this method is that the instruments are correct throughout their scales with regard to themselves. If the instruments are not correct, or even consistent with one another, but consistent each with its own scale, the result is not a false estimate of the efficiency of the machine, but merely some slight errors in the distribution of the loss of power. The machine will also be run at a slightly different load.

If very great accuracy is not required the machines need not be similar, for if they are both arc machines, or at least both work with the same currents, the motor M may be any machine that is powerful enough. Care must then be taken to assess the loss of power and of belt slip properly.

If the machines are at the same speed the belt slip may be avoided by coupling the shafts of the machines together rigidly, as in Dr. Hopkinson's method. This lessens the friction of the bearings if the shafts are set exactly true, but the belt has the advantage that the machines are run more nearly under their normal conditions, and the tests are therefore more valuable, though the efficiency does not come out quite so high.

The arrangement in which the speeds of the dynamos with their normal currents depend solely on the relative diameter of the pulleys is defective, as it does not admit of any fine adjustment. This adjustment is managed by shunting one of the fields or one of the armatures. Thus, suppose G is found to run too fast, a shunt across either the brushes or the field of M will make it run slower.

If a low resistance voltmeter is used, with enough resistance in series to take the high electromotive force, it may itself take a current large enough to interfere with the test. An electrometer has not this disadvantage.

As our next example we will take two similar shunt or compound machines. First let them be shunt machines. We may suppose the test made with two Edison-Hopkinson machines like those tested at Manchester, particulars of which are given in *The Electrician* for 5th March, 1886. Fig. 2 shows two such

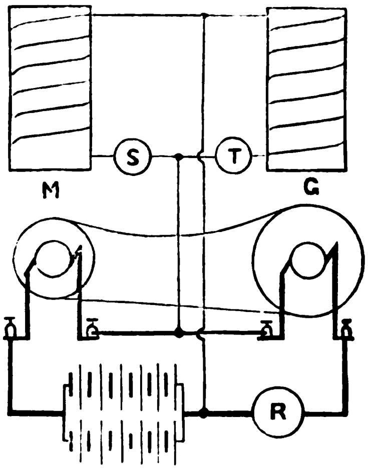

Fig. 2.

machines coupled with pulleys of different diameters. The first thing to do is to find the revolutions and relative sizes of the pulleys needed. The normal speed is 750, and the armature electromotive force $\mathfrak{E}$ is 108·6 volts, and ϵ and e are 105 volts. The machine is run as a motor with no load till it has a back electromotive force of 108·6 and a speed of 750. The field will then have a little less than 105 volts on it.

But the armature will be under conditions almost the same as when running at full load as far as Foucault currents, persistent magnetism, &c., are concerned. The electrical power now spent in the armature will give the data required for calculating the pulleys. Let the figures be 109 volts and 24 amperes in the armature, or 2,682 watts. The armature of the generator has a normal current of 364 amperes and an electromotive force of 108·6 volts. It will therefore want 39,600 + 2,682 to drive it; allowing 1 per cent. belt slip the motor must give 42,605 watts. As the motor will be going about 20 per cent. faster than the dynamo, 3,580 watts may be allowed for stray power, so the armature must get 46,185 watts. As the generator excites both machines the motor current is 352, and the back $\mathfrak{E}$ must be 131 volts; so the pulleys must be as 108·6 : 131. This assumes that the difference of current in the two machines makes no practical difference in the arma-

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ture volts. The electromotive force at the brushes of the motor is $\epsilon = 134{\cdot}5$, so secondary cells or another machine must be inserted to add 26 or 27 volts to give 134·5 volts on the motor. These cells then supply the loss in the whole system. The machines are coupled up as shown in Fig. 2. The cells are shown in the main circuit, and there is an adjustable resistance R in the main circuit; the shunt circuits have also an adjustable resistance in each. To start the whole system the main circuit is made; the connections must be made so that the fields are to some extent excited by the cells to start with—that is to say, the resistance R must be in the armature circuit, but not in the field circuit. One objection to this method of testing two shunt machines may be the difficulty of starting. To start, the resistance S in the motor field circuit may be taken out, and the field of the generator left open and then closed through a high resistance which is gradually taken out. Let us suppose the machine started, and the main resistance and the shunt resistance adjusted till the generator is running under its normal condition. The power lost in each field is then determined, and the loss by armature resistance is calculated for each machine; the loss not thus accounted for is the total loss through friction belt, &c., and is distributed in the same way as in the case of the series machines. If the first calculation of the sizes of the pulleys is wrong, the motor must have its field altered by the resistance S, but it is not likely the error will be large enough to allow any perceptible error in the distribution of the stray power.

(*To be continued.*)

NOTE ON LIGHTING LAMPS BY PRIMARY CELLS, OR BY A COMBINATION OF PRIMARY AND SECONDARY CELLS.

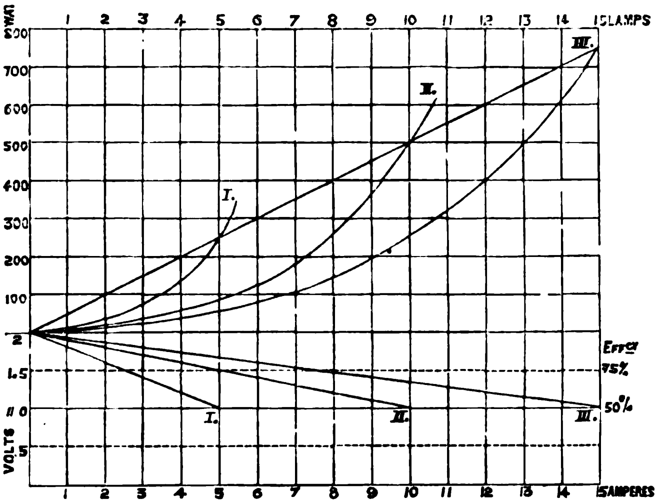
BY V. S. ALLPRESS.

Attention has often been called of late to the question of lighting by means of primary batteries, used either alone or in combination with secondary batteries, but little has been said of the relative efficiency of the two arrangements, and I have therefore worked out a few cases in order to show what the result might be in small domestic installations.

In Dr. Oliver Lodge's report on the Upward battery, the combined system of working is very favourably alluded to, and there is no doubt, if convenience alone is considered, such an arrangement has many advantages.

It will be seen, however, from the tables and diagrams that the cost of working is generally high, and that the output is somewhat restricted where lighting is to be done from a secondary battery, which is charged steadily for 24 hours, and discharged for a large portion of the same time; and it would appear, therefore, that if a simple automatic gear could be devised for switching in extra primary cells as the number of lamps in circuit increased, the difficulties of self-regulation, due to the high internal resistance of the batteries, would probably be overcome more cheaply than by the addition of a secondary battery.

In the examples I have taken it is assumed that 50-volt lamps requiring one ampere each are to be used, that the E.M.F. of each primary cell is two volts on open circuit, and that the internal resistance is one-fifth of an ohm per cell. It is also assumed that the efficiency of the system described by Dr. Lodge, in which one secondary and two primary cells are said to be needed for every couple of volts demanded in the circuit, is 50 per cent., although it is probably less than this; for, if 50 primary cells with the E.M.F. and resistance given



above are coupled up to 25 secondary cells, the charging current would vary from about five amperes when the back E.M.F. is only 50 volts to about three amperes when the E.M.F. of the charging current is allowed to rise to, say, 40 per cent. above the normal, during the latter part of the charging. It may be seen from the accompanying tables that the efficiency of primary cells would be 50 per cent. and 70 per cent. respectively when charging at these rates, and as the average efficiency of a secondary battery is not likely to exceed 70 per cent., the efficiency of the combination would be below 50 per cent. in any case, whereas that of a primary battery lighting lamps direct would in many small installations be much higher when the primary cells are arranged in two or three groups; and even with a single group, there is a distinct advantage on the side of a primary battery, if only a small number of lamps is required for many hours at a time.

I have tabulated the figures obtained in several cases, and it is only necessary to add that the lower part of the diagram refers to E.M.F. and efficiency of cells, and the upper part to the work done in lamps, and Curves I., II., and III. to that lost in the primary battery when arranged in one, two, and three groups.

PRIMARY BATTERY—SINGLE GROUP.

Number of Lamps in Circuit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of Cells in Series	28	31	36	42	50										
Efficiency per cent.	90	80	70	60	50										
2 Groups.															
Number of Cells in Series	26	28	29	31	33	36	38	42	45	50					
Efficiency per cent	95	90	85	80	75	70	65	60	55	50					
3 Groups.															
Number of Cells in Series	26	27	28	29	30	31	33	34	36	38	39	42	44	47	50
Efficiency per cent.	96	93	90	86	83	80	76	73	70	67	63	60	57	53	50

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BRITISH ASSOCIATION, 1886.

The following papers marked * were contributed to the late meeting of the British Association on various subjects connected with Electrolysis.

ON THE ACCURACY OF OHM'S LAW IN ELECTROLYTES.*

BY PROF. G. F. FITZGERALD, F.R.S., AND MR. TROUTON.

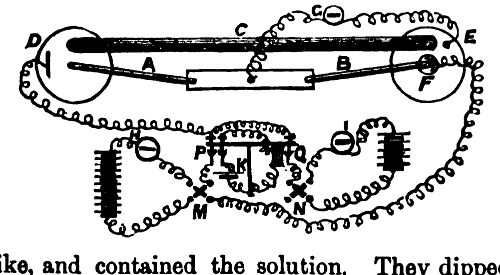
Some preliminary experiments were begun in the spring of this year, and have been carried on from time to time since, with a view to determining how far Ohm's law may be relied on in the case of electrolytes.

Though as yet no very high limits of accuracy in the experiments have been attained, owing to causes which will be later on explained, still it is hoped that from the experience already gained most of the difficulties have been got over, and that soon results of a much greater degree of accuracy will be arrived at.

The method adopted is that described in the British Association Report for Glasgow, 1876, which Prof. Chrystal, in connection with Clerk Maxwell, employed in the case of metal conductors, namely, that of a Wheatstone bridge, two of the arms of which are of about equal section and resistance, while the remaining two, though of equal resistance, are of very different sections. If Ohm's law be not true, the point of balance of the bridge varies with the amount of current passing through it. Balance having been obtained, the battery-power is altered, and if balance still subsists, the deviation from Ohm's law, if there be any, is such as cannot be detected with apparatus of the sensitiveness employed.

The great difficulty in experimenting in this way is that the change in the current alters the temperature of the two arms of unequal section very differently, and proportionately also their resistances. While the thick conductor alters little in temperature, the thin one alters considerably. Thus the point of balance is changed, even though Ohm's law be true. To avoid this effect it is necessary, having balanced with the large current, to immediately pass the smaller current before the temperature can sensibly alter. As this requirement is practically impossible to satisfactorily fulfil, the method employed is a rapid alternation of a large and small current. If Ohm's law be not true, a balance in this case can only be apparent, and on reversing the direction of one of them, the two currents, which before neutralised each other's action, now conspire to deflect the galvanometer. The mode of experimenting is to find balance with a large and a small battery alternately in circuit, and rapidly enough for the temperature during the smaller current to be sensibly the same as while the larger one is acting, then to change the direction of one of the currents and to again balance. The distance is observed between the two points of balancing, but if the bridge still balances it is assumed for the purposes of calculation that the distance is what the galvanometer employed only just detects. From this, from the two currents the section and resistance of the thin conductor, h is calculated where $e = rc(1 - hc^2)$, as is explained in the above-mentioned report.

The liquid, chosen for experimenting with, was a solution of copper sulphate in water. The equal arms consisted of two glass tubes bent at right angles at each end, A and B, arranged



syphon-like, and contained the solution. They dipped into a long narrow trough, as shown in the diagram. The arm of large section C, a tube 119cm. long and 2·38cm. in internal diameter, reached from the bowl D, into which the tube A also dipped, to the bowl E. The small arm was a hole ·055cm. in diameter, drilled in the side of the beaker F, ·062cm. in thickness, into which the tube B dipped.

The battery poles consisted of copper plates, one in the beaker, the other in the bowl D. The contact breaker was a T piece worked by an electromagnet and cell K, as shown in the diagram. One of the batteries contained ten Grove cells, the other five, and both could be thrown in circuit in either direction by means of the reversing keys M and N. By proper adjustment of the mercury cups P and Q one of the batteries went in circuit, just as the dipper on the other side, coming out of the mercury, threw the second battery out of circuit. By means of the galvanometers H and I it could be seen, during the course of an experiment, whether the contacts were working properly or not.

One of the copper wires leading to the galvanometer dipped into the bowl E, the other into the trough, and could be moved up and down it in order to obtain balance, the distance moved being read off a scale along the trough. There was always more or less of a permanent current through the galvanometer, even though the poles were both of copper; this, especially, as it was liable to sudden changes in amount, caused by moving the trough pole or by accidental shaking, necessitated the employment of the galvanometer in a comparatively insensitive condition. Various devices were tried with a view of avoiding this current, such as electroplating the poles, using chemically pure copper sulphate, or employing for poles either end of a broken wire, so as to have, if possible, metallically like poles. These were found to give an indication of current even in distilled water.

The resistance of the smaller arm was about 800 ohms, but owing to its smallness varied greatly with the current through the change of temperature. A good deal of trouble was experienced through the resistance of the smaller arm at times being less when the current passed in one direction than when it passed in the other. This occurred so often that until its cause was understood, and steps thus could be taken to prevent it, there was little hope of completing the experiments. After various attempts it was discovered to be due to the density of the solution on the outside of the beaker in the bowl being slightly different from that inside, so that the density in the hole, and consequently its resistance, depended on the direction of the current, the electric transfusion of the liquid always changing direction with the current.

A number of experiments were made of a more or less satisfactory nature; in all no difference in the position of balance was found on reversing one of the batteries. Taking the difference, then, to be what the galvanometer would just detect, h is calculated to be less than 10^{-4}. This is, of course, very large. The limit Prof. Chrystal reached in his experiments with metal conductors was less than 10^{-12}.

With a view to reaching a higher limit a smaller hole was next tried. It was ·17cm. in diameter drilled in a plate of glass ·022cm. thick. Its resistance was about 2,700 ohms, so that a longer tube had to be used for the large arm. The balance was always found to be very different when one of the batteries was changed in direction. However, this was probably entirely due to the difference in temperature during the small and large currents, for h calculated from this was not even as small as in the first experiments; also the difference between the balance points varied with the speed of the contact breaker. Unfortunately the contact breaker, which was adjustable in its rate of vibration, had reached its limit of speed, so that a completely new arrangement has now to be employed.

PROF. BOUTY ON ELECTROLYTIC CONDUCTIVITY.*

The author first describes Lippmann's method of measuring the resistance of electrolytes, viz., by tapping off and measuring the E.M.F. between two points of the liquid contained in a cylindrical tube, and comparing this with the E.M.F. tapped off a length of known wire included in the same battery circuit as the liquid. He proceeds to use it also for determining the polarisation of either electrode, by measuring the E.M.F. between one of the main electrodes supplying current to the liquid and one of the tapping electrodes; using the obvious relation

$$e = r\,C + p$$

in order to find p, the polarisation.

* Abstract by Oliver Lodge, made for the B.A. Committee on Electrolysis.

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With platinum electrodes and acidulated water he thus reckons that with a current of average intensity of about $8 \times^{-8}$ amperes per square centimetre, the polarisation of the electrode rises as follows:—

	Polarisation of the cathode is	Polarisation of the anode is
In 5 minutes	·056 volt.	·103 volt.
„ 40 „	·063 „	·166 „
„ 60 „	·065 „	·175 „

He then applies a slightly stronger current, but as it is very variable I do not see that the numerical results obtained are much good. However, the idea is that the polarisation of the cathode attains a maximum and begins even to diminish, while that of the anode goes on increasing.

He then measures the resistance of acid water in a long siphon tube, and considers that it is independent of current intensity, and asserts: "*A liquid has only a single way of conducting electricity, whatever may be going on at the electrodes. The expressions 'metallic conductivity' and 'electrolytic conductivity' ought to disappear from science.*"

Electrolysis of Mixtures.

A number of mixed salts are tried, one of them being always a salt of copper. Results are given for the electrolysis with copper electrodes of a mixture of sulphate of copper and sulphate of zinc, saturated in the cold, and are analysed thus: "For current intensities from 5 to 12 ten-thousands of an ampere per square centimetre the polarisation of the anode is constant and equal to ·0088 volt; but that of the cathode varies enormously. For an intensity 2·9 (ten thousandths of an ampere as before) it is already ·02 volt; it increases slowly with the current and is sensibly constant for the same current when prolonged. But at an intensity 8·6 a new phenomenon is produced; polarisation increases with time, first very slowly, then more and more rapidly, going from ·04 to ·65 volt; at the same time one notices that the metallic and brilliant deposit of pure copper which one had hitherto obtained is displaced by a ruddy and non-adhesive deposit. In proportion as it is produced the polarisation increases, and the deposit overspreads the electrodes with increasing rapidity.

"Finally, augmenting the current still more, the deposit passes gradually from red to black, while polarisation increases in a continuous manner, and for a sufficient current intensity the deposit acquires anew a certain adherence. It is then dark grey, very rich in zinc, and recalls by its aspect deposits of zinc obtained from impure commercial sulphate of zinc.

"*As for the conductivity of the liquid it remains constant all the time, in spite of the variety of electrolytic actions,* to which a study of polarisation and aspect of deposit bear witness. . . . The same *kind* of thing happens with other proportions of $CuSO_4$ and $ZnSO_4$. . . .

"One may remark further that the specific resistance of the liquid passes through a minimum for a certain composition of the mixture; it is then inferior to the resistance of even a saturated solution of one of the salts, and *à fortiori* to that of the same salt diluted down to the strength in which it occurs in the liquor. *So the molecules of two mixed salts take part in the transport of electricity, even when only one of the two metals is deposited on the cathode.*"

All the variations of polarisation in the above case are then simply and naturally explained by the fact of exhaustion, in the liquid near cathode, of the salt of the metal being deposited, except in so far as diffusion replenishes it. With strong currents it is therefore plainly necessary for zinc to be deposited as well as copper, and it is equally obvious that this zinc will tend to clear itself off again by local action.

The author then goes on to observe that very similar complications occur even when only one salt is intended to be present. Thus pure $CuSO_4$ almost always contains a trace of acid, and accordingly, in its solution, hydrogen plays much the same part as zinc has done in the above described experiment. For feeble intensities copper alone is deposited, but for stronger currents the deposit is red and contains some oxide [?]. Hydrogenised copper forms with copper, in fact, local couples in which copper is the attacked element. Evolution of heat by local action has been proved by the use of thermometer electrodes.

Even if $CuSO_4$ contained no acid to start with, it would soon get some by electrolysis;† for the solution of anode is never exactly equal to deposit on cathode.

ON DIATHERMANCY AND ELECTROLYTIC CONDUCTIVITY.*

BY SHELFORD BIDWELL, ESQ., F.R.S.

The following is one of the questions suggested by Dr. Lodge for the consideration of the committee on electrolysis:— Is there any relation between optical opacity and electrolytic conductivity?

Assuming that "optical opacity" is included in the more comprehensive term "opacity to radiation," I have endeavoured to ascertain experimentally whether those electrolytes which transmit radiation with the greatest facility, as evidenced by the effect produced upon a thermopile, are also the worst conductors of electricity. I may say at once that this was undoubtedly not the fact, and the relation which was supposed to be possible does not exist.

Considerable time and care were bestowed upon the experiments, and every precaution was taken with the view of ensuring accuracy. The thermopile used was a delicate one, containing 54 bismuth-antimony pairs; it was enclosed in a flannel-covered box, fitted with a pane of glass 1·5mm. thick opposite the face of the pile. The galvanometer was an astatic reflecting instrument of ·545 ohm resistance made by Elliott. The source of radiation was a small paraffin lamp, having a glass chimney about 2mm. thick.

The parallel glass sides of the cells, used to contain the liquids, were 13mm. apart, and 1·9mm. in thickness. A screen, with a small aperture, which could be instantly opened or closed by a sliding shutter, was interposed between the cell in use and the lamp. The various solutions were in every case exposed to radiation for a period of 30 seconds, and each observation was checked and standardised by the aid of a certain cell containing water. It is hardly necessary to describe the arrangements and method of observation in greater detail.

A few of the results, which, for the most part, need no comment, are given in the following table:—

Solutions, &c.	Diathermancy.
Empty cell	1,000
Water distilled	197
„ from tap	200
Alum, saturated solution	204
Ammonium chloride solution	215
Zinc sulphate sol. sp. gr. 1·157	207
Sulph. acid 1·032 (5 per cent.)	208
„ „ 1·225 (30 „)	216
„ „ 1·638 (72 „)	292

The observations with sulphuric acid are the most instructive. It is well known that the electrical conductivity of sulphuric acid at first increases with the concentration, reaching a maximum when the strength of the solution is about 30 per cent., and afterwards rapidly diminishing. That there is no corresponding minimum diathermancy appears clearly enough from the above table, which seems to furnish a conclusive answer in the negative to the question proposed.

The diathermancy of a solution of zinc sulphate was almost independent of its strength, being nearly the same for a 5 per cent. as for a saturated solution. It was quited unaffected by the passage through the solution of a strong battery current.

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† *Göttinger Nachrichten*, February 25, 1885.
† *Bihang till K. V. Akad. Handl.* VIII. No. 13, p. 45.
† *Compt. Rend.* February 11, 1884.
† *Göttinger Nachrichten*, 1885, p. 26.
† *Journal de Physique*, 1882, 2e série, t. i. p. 346.
† Unless one artificially keeps it neutral: see D'Almeida, *Annales de Chemie*, 3e série, t. ii. p. 257.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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VOLUME XVII.

Volume XVII. of "The Electrician," price 10s. 6d., is now ready.

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CONTENTS.

Notes 25
Elementary Electricity and Magnetism—II. (Continued.) Illustrated 30
Testing Dynamo Machines. By J. Swinburne (Continued.) Illustrated 31
Note on Lighting Lamps by Primary and Secondary Cells. By V. S. Allpress. Illustrated 33
On the Accuracy of Ohm's Law in Electrolytes. By Prof. G. F. Fitzgerald, F.R.S., and Mr. Trouton. Illustrated 34
Prof. Bouty on Electrolytic Conductivity 34
On Diathermancy and Electrolytic Conductivity. By S. Bidwell, F.R.S. 35
The Metropolitan Board of Works and Overhead Telegraph Wires 36
Correspondence .... 37 to 39
New Zealand Cables 39
M. Deprez on on the Experiments of M. Fontaine 39
Dynamo-Electric Machinery. By J. Hopkinson, M.A., and E. Hopkinson, M.A. Illus... 39
Society of Telegraph-Engineers 43
Physical Society 43
Legal Intelligence 44
Companies' Meetings—
West India and Panama Telegraph Company 44
Pilsen Joel and General Electric Light Company 46
Companies' Share List 46

THE METROPOLITAN BOARD OF WORKS AND OVERHEAD TELEGRAPH WIRES.

We are glad to observe that the METROPOLITAN BOARD OF WORKS has not allowed to drop out of notice the question of overhead telegraph wires in the Metropolis. The Works and General Purposes Committee have made their report, after a prolonged inquiry, which was ordered to be instituted last January; and although a Committee of the House of Commons meanwhile has reported in a sense rather favouring non-interference, the chief governing body of London has resolved not to slacken its efforts for the better regulation and consequent abatement of a peril and nuisance which, but for the peculiar circumstances of the case, would never have been permitted to arise. The overhead wire system came into being without protest, and secured a footing for many years, because nobody could foresee the sudden and gigantic extension which it actually underwent in consequence of the invention of the telephone. Proceeding on the established assumption that nobody's leave to erect wires need be asked except the owners of houses to which they had to be affixed, the Companies pushed on their operations unchecked, until interference would have seemed arbitrary or confiscatory; and they have enlisted public convenience on their side to such an extent that it has become almost impossible to check them without doing their customers a great disservice.

Taking advantage of the legal uncertainties which surround the question, the Companies have made a point of thickening their network of wires and of carrying them in every possible direction, so as to create a precedent for every conceivable step which their business may some day require. No edifice has been too sacred for them to invade, and no thoroughfare too crowded for them to imperil. The more incongruous the connection between wires and structure the better the companies like it; and wherever a busy street has to be crossed the angle adopted invariably threatens the greatest number of people. Observing these things, an unreflecting public is apt to say they have done their worst. This is precisely what the Companies desire should be said, and they have lost no time about it. But for these exceptional features of the case we should be disposed to echo the reformist's impatient cry—Why should London wait? We see, however, quite plainly why London has to wait for this particular reform; and are almost as much surprised as pleased that the METROPOLITAN BOARD OF WORKS perseveres in its efforts to put the wires under proper legal control. We know of only one restriction to which the companies are at present liable. It is stated that they complain of the Post Office, where it retains control over wires running by the side of the railroads, refusing permission for telephone wires to cross the lines overhead. If this is true, the prohibition must be due solely to there being somebody who has power to protect passengers travelling in railway trains—a protection which does not exist for the protection of passengers travelling on foot.

It has been generally asserted by the defenders of the overhead wire system that its dangers have been much exaggerated; and, if we mistake not, this is a view of the question countenanced by some authorities of the Post Office. The Post Office can speak for itself with confidence, no doubt; its overhead wires are comparatively few in number, and we believe are decreasing rather than increasing. They are probably as securely erected as work done by a responsible State Department ought to be, and we may be sure that neither the position nor the numbers of its wires will provoke any public outcry. Still, the Post Office owns a good many overhead wires in the metropolis, besides having possibly in view the prospective ownership of all the other wires. This may account for the lukewarmness displayed in that quarter when proposals are being made to get our urban telegraph systems put under ground. But it is scarcely fair to the public to lend a high authority to the statement that there is little or no danger from overhead wires. The experience of last winter afforded ample proofs of the contrary. If few people were maimed or killed by the wreckage of falling wires during the great storm, it was a marvel of mercy, not an evidence of security. A house may fall without hurting anybody, but that is not a reason for neglecting the inspection of buildings; and although a telegraph wire is not so certain to do injury if it fall as the wall of a badly built house, it is far more likely to fall; and, unlike the house, the older it is the more dangerous it becomes. The danger we refer to has multiplied ten thousand times in the streets of London during the past five or six years, and goes on increasing at an alarming rate. It is possible to exaggerate the accidents due to falling telegraph wires, but one can hardly exaggerate the risks we are needlessly incurring by their indiscriminate erection. The action of the Post Office referred to above is taken, no doubt, for the safety of their own wires; but human life is quite as valuable as Post Office wire, and runs far greater risks from telephone wires crossing the streets of a busy town.

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About one ground of objection to the increasing network of wires which is rapidly enclosing this great city there can be no exaggeration. Utility may, and does, reconcile us to many unsightly objects both in town and country life; and when the disfigurement is a necessity we have only to grin and bear it. But in this relation the constant aim of *The Electrician* has been to inform the public that the disfigurement complained of is not a necessity; that, on the contrary, it could have been easily avoided by a little foresight on the part of the local authorities, and a little prudence on that of the offending Telephone Companies. Even now it would be cheaper to commence laying wires underground than to postpone the operation indefinitely. Obviously, it will have to be done sooner or later. The burden of the wires will within measureable distance of time become unbearable, even if the offence against public taste be still condoned. That the nuisance should be endured so long can only be explained by popular ignorance of the problem to be solved. All sorts of misleading statements are made current as to the expense of laying wires in underground channels, and the difficulty of maintaining them in working order. The experience of the Post Office's underground system, which is of considerable extent, and the results of trials already made in America, are conclusive on both these points. We have no hesitation in saying that in the long run the underground system, at all events in populous towns, is cheaper and more efficient than any overhead system can possibly be, and has the permanent advantage of exciting no opposition either on the score of bodily danger or æsthetic offence. We are certain that public taste will not long permit the best architecture of the most variedly picturesque city in the world to be wantonly disfigured when the fact becomes known that, without any substantial injustice, the Companies could be forced to lay their wires out of sight. Nobody desires to see the offending parties suffer for the neglect of the parish authorities or the uncertainties of the law; but when these have been strictly defined, as we may hope will now soon be done, there can be no longer any excuse for that defiance of public opinion which has characterised the proceedings of Telephone Companies ever since they started business.

CORRESPONDENCE.

THE CHARACTERISTICS OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: From the report in your issue of November 12, p. 20, I have become acquainted with Mr. Kapp's recent paper before the Society of Telegraph-Engineers and Electricians; and I desire, with your permission, to make a few remarks on it.

The main point of the paper is the estimation of the magnetic resistance of a magnetic circuit, as made up of the metallic resistances involved, plus the resistance of the air spaces, and it appears that this was published by Mr. Kapp about a year ago.

I think I ought to claim for myself that I believe I was the first to propose this method. I am far from wishing to say that Mr. Kapp has taken his work from me.

In a paper presented to the Royal Society on December 20, 1882, "On a Uniform Rotation Machine, and on the Theory of Electro-magnetic Tuning Forks," I developed a theory of magnetic circuits having substantially the same outline as that above stated. For abstract see *Proc.* R S., XXXIV., 445.

The same point of view was treated in some detail by Rowland in an address to the Congress of Electricians at Philadelphia, reported in your issue of Oct. 18, 1884, and following numbers. The report is somewhat imperfect; and in commenting on the subject (*Electrician*, XIV., 292), I said that it was necessary to wait for a fuller report. Unfortunately, I had got it into my head that it was a British Association Address, and so missed it. The paper would undoubtedly be worth your reprinting in full, if you can procure it.

As to Mr. Kapp's discussion of the law of magnetisation, I have been long engaged in experiments with a view to clearing this up. The ultimate completion of these is still far off. But I hope shortly to make use of certain completed results to give a partial discussion on general grounds in the *Phil. Mag.*

One more point. The statements as to saturation on page 21 of report of Mr. Kapp's paper are strange. The units employed are a terror. The mixing up of inches with C.-G.-S. at this time of day is really to be deprecated. However, I think I see what is meant, and have reduced his numbers to C.-G.-S. inductions, so as to be directly comparable with Rowland's and my results. I am not acquainted with Mr. Hopkinson's, but shall be surprised if they differ much from ours.

It appears from these numbers that the comments of Mr. Kapp, to the effect that his saturation numbers are higher than ours, are not at all justified, as far as wrought iron is concerned. On the contrary, his number for wrought iron is approximately the same as the number attained by Rowland, and much less than many of the numbers I have attained.

Mr. Kapp's numbers for charcoal iron are no doubt much greater than Rowland's or my highest numbers for charcoal rings. But I am curious to know how Mr. Kapp measured the magnetised sections in his wires and discs—a matter which seems to me of the greatest difficulty.

I should notice that such experiments as are available, other than Mr. Kapp's, place the saturation field of charcoal iron at about the same value as that of ordinary wrought iron. The advantage of charcoal iron is in the region of maximum permeability ($\mathfrak{B} = 5{,}000$ to $10{,}000$); here the permeability is enormous, as we find by measures of rings. But in the saturation region it is not a bit better than ordinary wrought iron.

As I have frequently noticed in recent papers, the saturation field in the equatorial sections of magnets with ends (bars) can be forced up very much higher than in rings of the same material.

I append a table of the chief saturation numbers attained by Mr. Kapp, Rowland, and myself, together with my calculation of Mr. Kapp's numbers, this last for your own satisfaction.

[For calculation of Kapp's numbers see below.]

WROUGHT IRON.

		Observed Highest $\mathfrak{B}$.
Kapp	Field magnets "18 lines"	16,740
Rowland	Ring, *Phil. Mag.* XLVI. (1875) 151	16,600
Bosanquet	Ring E, *Phil. Mag.* XIX. (1885) 76	17,245
"	Ring F	18,834
"	I (Lowmoor)	19,303
"	Bar. I., *Phil. Mag.* XVII. (1884) 532	19,650
"	Bar. II.	21,428
"	Plain Bar. I.,* *Phil. Mag.*, Sept., 1886, p. 300	29,388
"	Plain Bar. II.*	27,688

CHARCOAL IRON.

Kapp	Armatures, wire, "25 lines"	23,250
"	Armatures, discs, "22 lines"	20,460
Rowland	Ring, *Phil. Mag.* XLVI. (1873) 153	16,850
Bosanquet	Ring, *Phil. Mag.* XX. (1885) 321 ...	18,146
"	Ring	18,277

* The reference is to the description of the bars. The actual observations are not there given, such use of them only being made as is required for the purposes of the paper. The two bars came from the same piece of iron.

—Yours, &c., R. H. M. BOSANQUET.

S. John's College, Oxford.

Reduction of Mr. Kapp's saturation values in "lines of force" (*The Electrician*, November 12th, 1883, p. 21) to $\mathfrak{B}$ (C.-G.-S.),

2·54 centimetres = 1 inch.

$$\begin{array}{r} \log 2{\cdot}54 = {\cdot}40483 \\ 2 \\ \hline {\cdot}80966 \end{array} = \text{log. sq. centimetres per sq. inch.}$$

A field of 6,000 units C.-G.-S. is taken for "unit line of force."

$$\therefore \text{C.-G.-S. field is "lines of force"} \frac{\times 6000}{\text{sq. cents. per sq. inch}}$$

log 6,000 = 3·77815
log cents. per sq. inch = ·80966
2·96849 = log factor 930·01.

"Lines of Force."

log 25 = 1·39794		
2·96849		B
4·36643 = log		23,250
log 22 = 1·34242		
2·96849		
4·31091 = log		20,460
log 18 = 1·25527		
2·96849		
4·22376 = log		16,740

Rowland's Q's are divided by 10 to reduce to C.-G.-S., as he worked on the metre-gramme-second system.

SECONDARY BATTERY PLATES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the correspondence columns of your last issue attention is called to a patent specification, No. 8540, 1885, with reference to the form of secondary battery plates lately put forward somewhat prominently by Mr. P. Gadot, of Paris, the form and arrangement claimed being lead plates with conical perforations, packed with oxide of lead, and fixed face to face, so as to retain the active material in position.

I would mention that in my specification, No. 3926, September 10, 1881, I fully describe and illustrate the fixing together of two packed perforated plates, and in a later specification, No. 2818, June 15, 1882, the use of conical and other suitably formed perforations for keeping in or retaining the active material.

Such double plates were experimented upon by me in 1881-2, but they have some obvious disadvantages both in their primary manufacture, cost, and subsequent use.

With regard to the attachment of the active material to the ordinary *single* grid plates, if well made and properly treated, no difficulty occurs, the falling out of the solid cones or squares of peroxide of lead arising only when bad workmanship or usage come into play. I have had such plates in continuous use for more than four years, from which not a single plug of active material has become detached or loosened.
—Yours, &c., JOHN A. SELLON.

Sydenham Hall, November 15th, 1886.

SUNDAY AT OUR POST OFFICES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On the occasion of the election of mayors for the cities and towns of the United Kingdom yesterday many graceful allusions were made to the fact that during this year's mayoralty the Sovereign would complete the fiftieth or Jubilee year of her reign. Such an event is rare in the history of any country, and since the year 827—1,060 years ago—it has happened in this country only on three occasions. Henry III. completed the fiftieth year of his reign in 1266, Edward III. in 1377, George III. in 1810.

How Her Majesty's subjects may best celebrate the Jubilee of their Queen is a question which is receiving much attention. Various suggestions have been made, and no doubt every town and village will take part in the rejoicings, and in most cases accomplish some object which shall fitly commemorate the event, and substantially benefit the community.

In connection with this remarkable occurrence I should like to appeal to every person in the kingdom on behalf of the vast army of Post Office *employés* throughout the provinces whose onerous duties deprive them of the day of rest. I feel sure that all thoughtful and considerate people will agree with me that the time has arrived when the performance of unnecessary Sunday duty at the post offices may be altogether dispensed with.

Just fifty years will have expired next year since Dr. Wheatstone invented the electric telegraph system, which now spreads itself like a network over all the land, reaching every town and almost every village, and which enables us to have instant communication with each other in any part of the British Isles for the small fee of sixpence.

Three years after Her Majesty's accession, and two years after her coronation, viz., in 1840, Mr. Rowland Hill succeeded in obtaining parliamentary sanction to the introduction of his penny postage system, which has conferred inestimable advantages and blessings on the country at large. In 1855 the repeal of what have been called the "taxes on knowledge," viz., the newspaper stamp, the advertisement duty, and the excise duty on paper was brought about through the exertions of Mr. Thomas Milner Gibson, at that time the colleague of Mr. John Bright in the representation of this city.

Since 1870 we have been enabled to send post cards, circulars, and newspapers at the cost of a halfpenny.

The money order and postal order system, the annuity system, the Post Office Savings Bank, the Registered Letter Department, and the Parcels Post, have all been established during the reign of Queen Victoria.

It is remarkable that in the face of all the Post Office reforms which have been instituted within the last fifty years, there still exists a custom unworthy of the present age of progress, viz., the practice of employing in the provincial post offices large numbers of men and women in the performance of Sunday duties, which are regarded as unnecessary, and never have been performed in the metropolis.

Although London is the most populous and the greatest commercial city in the world, there has never been a Sunday delivery of letters there. If the 4,000,000 residents in the metropolis, and the thousands of visitors and strangers who are always to be found there, can, without inconvenience, dispense with the receipt and despatch of letters on Sundays, can there be any legitimate reason why the provinces should not be placed upon the same footing?

The question was argued in the House of Commons 36 years ago, and by a large majority it was resolved to abolish Sunday labour at all provincial post offices. An agitation was afterwards got up against this reform, and Lord John Russell, then the head of the Government, yielded to the pressure thus brought to bear.

But whatever arguments might be used then as to the inconvenience of the public in cases of emergency, they have no force to-day. We have, as I have said, facilities for communicating by telegraph which did not then exist.

Again, commercial travellers, who in consequence of the dearness and slowness of railway travelling thirty-six years ago were obliged to remain "on circuit" over the week end, are able to reach home on Saturday at small cost, and in a very short time. Since, therefore, they now spend their Sundays at home with their families they have no longer any need for the Sunday post.

At the time I speak of many merchants lived in the towns on or near their business premises. Now they live in the suburbs or in country places, and do not care to have letters delivered on Sundays. In many instances the Post Office authorities are requested *not* to deliver on that day. In other cases, where letters are taken out by the letter carriers on Sunday, they cannot be delivered for the reason that many people are absent from their houses, and also that places of business are closed.

The number of people employed at the post offices of the United Kingdom is close upon 100,000, a very large proportion of whom are employed during the Sunday in doing work which I am sure can be dispensed with.

A little consideration for these useful and industrious public servants, and a small personal sacrifice on the part of the public, would lead to the total abolition of Sunday labour at the Post Office, excepting in the Telegraph Department, and even this would be reduced, as the inclination to send telegrams is very frequently occasioned by the receipt of business letters.

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If the Jubilee year of the reign of the Queen should be signalised by the legislative prohibition of Sunday deliveries and despatches of letters, it will ever be memorable as being associated with a most beneficent and much needed reform.

Should any excuse be needed for this public appeal from one not immediately interested in the Post Office, it will be found in the fact that by the regulation of the Department letter carriers and others are forbidden to agitate for any cessation or reduction of Sunday labour.—Yours, &c.,

ELLIS LEVER, F.S.S.

Manchester, November 10, 1886.

NEW ZEALAND CABLES.

The following is a reference by the London correspondent of the *Manchester Guardian* to the questions under discussion between the Eastern Extension Telegraph Company and the New Zealand authorities. We have reason to believe that this statement gives correctly the latest phase of the discussion :—

"Since I referred some days ago to the dispute between the Eastern Extension Telegraph Company and the Government of New Zealand the quarrel has assumed a new aspect. The Government of New South Wales and Victoria showed their disapproval of the attitude of Sir Julius Vogel by refusing to collect the New Zealand terminal charges levied in Australia before the despatch of cable messages, and this week there was a prospect of the cable service coming to a standstill. Yielding to the suggestion of Sir Dillon Bell the Agent-General of New Zealand, the Extension Company have decided to withdraw their new tariff, to impose the old charges without any subvention, and to give lower press rates till the whole question can be settled by the New Zealand Parliament This concession at any rate shows the desire of the Extension Company to consult the public interest."

M. DEPREZ ON THE EXPERIMENTS OF M. FONTAINE.

At the meeting of the *Academie de Sciences*, held on the 2nd inst., the following note was read by M. Deprez :—M. Fontaine has lately submitted to the Academy an experiment on the transmission of power by electricity, by means of a process which he considers novel, and which consists in substituting for the generating and the recipient machines a collection of machines connected in series, and in such a number that the sum of their electromotive forces makes up the value which it is desired to obtain. In the experiment in question the number of generators was four, and the number of the recipients three. This idea is far from novel, and it has been proposed by all the electricians who have sought to obtain high tensions without having recourse to the construction of the special machines which I have been the first to realise.

As for the method employed by M. Fontaine to govern simultaneously the four rings of the generators, it much resembles that described in a patent which I took out on April 28th, 1885, in which I gave precisely an example of the application of this procedure to a machine with four rings of 0·30 metre in diameter and 0·20 metre in length like those of the machine which served for the experiments in the works of the Northern of France Railway in February, 1883. There was thus produced an apparatus, each ring of which could give a force of 1,500 volts at 1,000 turns per minute, the internal resistance of a ring being 5·5 ohms, and the total resistance of the four inducers being 15 ohms. The weight of the acting parts was composed of :—

Soft iron	1,124 kilos.
Copper	652 „
Total	1,776 „

On adding 600 kilos. for the support, it will be seen that we had arrived at a total weight below 2,500 kilos. for a machine with four rings capable of producing 6,000 volts and 10 amperes at the speed of 1,000 turns per minute. This is half the weight of M. Fontaine's four machines. These results admit of no doubt, since they are obtained by the addition of the effects of identical machines perfectly known.

But this project was not continued, because the conditions laid down for the experiments at Creil were quite different. The machines of M. Fontaine revolved at the speed of 1,300 turns per minute ; those at Creil made only 500 turns in the same time. The linear speed of the rings of M. Fontaine is 20·5 metres per second, as against 7·5 metres for those at Creil. If I had given the latter a linear speed of 20·5 metres they would have yielded an electromotive force exceeding 16,000 volts. The conditions are in no manner comparable, as it will be seen, and if the Creil machines are heavy it is simply because only a very low speed is required of them, and nothing has been done to lighten them. If in the arts we were to compare machines among themselves, taking lightness as the main condition, the engines of torpedo boats would be far superior to those in factories, and yet the use of the latter is far more general, though they are much heavier per unit of power. The reasons for this preference are too evident to require explaining.

In this order of ideas M. Fontaine's expedient is the same as that of the manager of a factory, who, instead of a single engine of 100 horse-power, moving slowly and surely, should prefer to employ four small engines of 25 horse-power each, moving at a very high speed, and acting upon the same shaft by means of mechanical transmission, having for their object the reduction of the speed.

M. Cabenallas said a few words in justification of the plan of using several machines connected in series, in preference to one large machine.

At the next meeting of the Academie, on Nov. 8, M. Fontaine replied to M. Deprez's criticisms categorically, as follows :—

1. The plan of coupling several machines in series to obtain a higher tension was first described by M. Gramme in 1872, and in our note nothing is said which could lead to the supposition that we thought the idea to be novel.

2. The means by which the four generators are simultaneously regulated, were first described and employed by MM. Celosétien et Félix, in 1879. If M. Deprez has taken out a patent for the arrangement in 1885, no doubt he was in ignorance of this anticipation.

3. We did not in our note institute any comparison between our own experiments and those at Creil, but it would be easy to show that the speed of our machines cannot be considered excessive, since there are actually in existence more than 1,000 Gramme machines, which have been running at the same speed for the last 10 years without needing repair.

Our only claim to novelty lies in the thoroughly practical character of the results which we have shown. Never, until now has 50 horse-power been transmitted through a resistance of 100 ohms, with a return of 52 per cent., by means of dynamo machinery weighing altogether not more than 8,400 kilogrammes, and costing only 16,450fr.

If, in practice, it is usual to prefer one large engine running at a slow speed to several smaller engines running more quickly, this is chiefly in order to realise an economy of fuel. M. Deprez's comparison is not, therefore, a happy one, since with his heavy machines he has not obtained a return of more than 44 per cent., while we have obtained a decidedly higher efficiency.

DYNAMO-ELECTRIC MACHINERY.*

BY J. HOPKINSON, M.A., D.Sc., F.R.S., AND E. HOPKINSON, M.A., D.Sc.

Theoretical Construction of Characteristic Curve.

Omitting the inductive effects of the current in the armature itself, all the properties of a dynamo machine are most conveniently deduced from a statement of the relation between the magnetic field and the magnetising force required to produce that field, or, which comes to the same thing, but more frequently used in practice, the relation between the electromotive force of the machine at a stated speed and the current around the magnets. This relation given, it is easy to deduce what the result will be in all employments of the machine, whether as a motor or to produce a current through resistance, through an electric arc, or in charging accumulators ; also the result of varying the winding of the machine, whether in the arma-

* From the *Philosophical Transactions* of the Royal Society.

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ture or magnets. The proper independent variable to choose for discussing the effect of a dynamo machine is the current around the magnets, and the primary relation it is necessary to know concerning the machine is the relation of the electromotive force of the armature to the magnet current. This primary relation may be expressed by a curve (Hopkinson Mechan. Engin. Instit. *Proc.*, 1879, pp. 246 *et seq.*, 1880, p. 266), now called the characteristic of the machine, and all consequences deduced therefrom graphically ; or it may be expressed by stating the E.M.F. as an empirical function of the magnetising current. Many such empirical formulæ have been proposed ; as an instance we may mention that known as Fröhlich's, according to whom, if c be the current in the magnets, E the resulting E.M.F., $E = \frac{a c}{1 + b c}$. For some machines this formulæ is said to express observed results fairly accurately, but in our experience it does not sufficiently approximate to a straight line in the part of the curve near the origin. The character of the error in Fröhlich's formula is apparent by reference to curves in Diagram A, which gives a series of observations on a dynamo machine, and for comparison therewith a hyperbola F, drawn as favourably as possible to accord with the observations.* Such empirical formulæ possess no advantage over the graphical method aided by algebraic processes, and tend to mask much that is of importance.

One purpose of the present investigation is to give an approximately complete construction of the characteristic curve of a dynamo of given form from the ordinary laws of electro-magnetism and the known properties of iron, and to compare the result of such construction with the actual characteristic of the machine. The laws of electro-magnetism needed are simply (Thomson, papers on "Electrostatics and Magnetism;" Maxwell, "Electricity and Magnetism," Vol. 2, pp. 24, 26, and 143), (1) that the line integral of magnetic force around any closed curve, whether in iron, in air, or in both, is equal to $4 \pi n c$ where c is the current passing through the closed curve, and n is the number of times it passes through ; (2) the solenoidal condition for magnetic induction—that is, if the lines of force or of induction be supposed drawn, then the induction through any tube of induction is the same for every section. Regarding the iron itself, we require to know from experiments on the material in any shape the relations between α, the induction, and a, the magnetic force at any point ; for convenience write $a = f^{-1}(\alpha)$, or $\alpha = f(a)$. From these premises, without any further assumption, it is easy to see that a sufficiently powerful and laborious analysis would be capable of deducing the characteristic of any dynamo to any desired degree of accuracy. This we do not attempt, as even, if successful, the analysis would not be likely to throw any useful light on the practical problem. We shall calculate the characteristic, first making certain assumptions to simplify matters. We shall next point out the nature of the errors introduced by these assumptions, and make certain small corrections in the method to account for these sources of error, merely proving that the amount of these corrections is probable, or deducing it from a separate experiment, and again compare the theoretical and the actual characteristic.

First Approximation.—Assume that by some miracle the tubes of magnetic induction are entirely confined to the iron, excepting that they pass directly across from the bored faces of the pole-pieces to the cylindrical face of the armature core. This, we shall find, introduces minor sources of error, affecting different parts of the charcteristic curve to a material extent. Let I be total induction through the armature, A_1 the area of section of the iron of the armature, l_1 the mean length of lines of force in the armature, A_2 the area of each of the two spaces between core of armature and the pole-pieces of the magnets, l_2 the distance between the core and the pole-piece, A_3 the area of core of magnet, l_3 the total length of the magnets. All the tubes of induction which pass through the armature pass through the space A_2 and the magnet cores, and by our assumption there are no others. We now assume further that these tubes are uniformly distributed over these areas. The induction per square centimetre is then $\frac{I}{A_1}$ in the armature core, $\frac{I}{A_2}$ in the non-magnetic spaces, $\frac{I}{A_3}$ in the magnetic cores ; the corresponding magnetic forces per centimetre linear must be $f\left(\frac{I}{A_1}\right)$, $\frac{I}{A_2}$, $f\left(\frac{I}{A_3}\right)$. The line integral of magnetic force round a closed curve must be $l_1 f\left(\frac{I}{A_1}\right) + 2\, l_2 \frac{I}{A_2} + l_3 f\left(\frac{I}{A_3}\right)$. In this approximation we neglect the force required to magnetise pole-pieces and

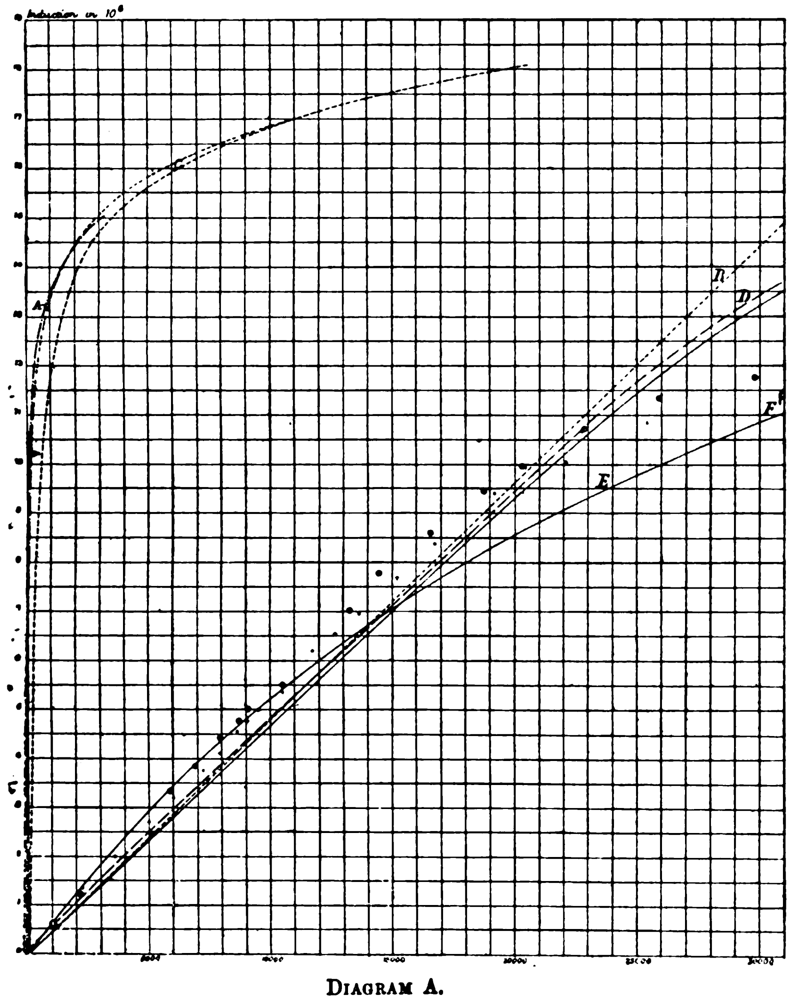

DIAGRAM A.

Approximate Synthesis of characteristic curve :—A, armature. B, air space. C, magnets. D, deduced curve. E, observed results, + ascending, (+) descending. F, Frohlich's curve.

[* Added August 17th.—That Frölich's formula cannot be a thoroughly satisfactory expression of the characteristic of a dynamo machine is evident from the consideration that E should simply change its sign with c, that is, be an odd function of c. There should be a point of inflexion in the characteristic curve at the origin. Another empirical formula $\frac{E}{a} = \tan^{-1}\frac{c}{b}$ is free from this objection, but still fails to fully represent the approximation of the curve to a straight line on either side of the origin, and it is equally uninstructive with any other purely empirical formula.]

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other parts not within the magnet coils to avoid complication. The equation of the characteristic curve is then $4\pi n c = l_1 f\left(\frac{I}{A_1}\right) + 2 l_2 \frac{I}{A_2} + l_3 f\left(\frac{I}{A_3}\right)$. This curve is, of course, readily constructed graphically from the magnetic property of the material expressed by the curve $a = f(a)$. In Diag. A curve A represents $x = l_1 f\left(\frac{y}{A_1}\right)$, the straight line B $x = 2 l_2 \frac{y}{A_2}$, curve C $x = l_3 f\left(\frac{y}{A_3}\right)$, and curve D the calculated characteristic. When we compare this with an actual characteristic E, we shall see that, broadly speaking, it deviates from truth in two respects :—(1) It does not rise sufficiently rapidly at first; (2) it attains a higher maximum than is actually realised. Let us examine these errors in detail.

(1) The angle the characteristic makes with the axis of abscissæ near the origin is mainly determined by the line B. We have, in fact, a very

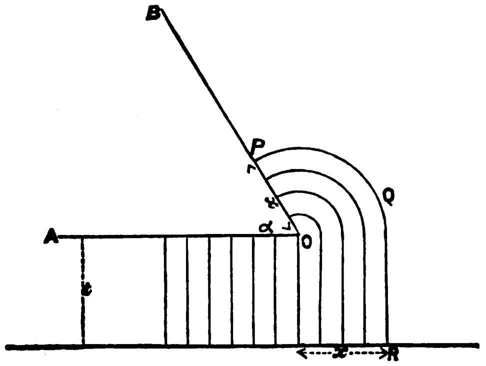

Fig. 1.

considerable extension of the area of the field beyond that which lies under the bored face of the pole-piece. The following consideration will show that the extension may be considerable. Imagine an infinite plane slab, and parallel with it a second slab cut off by a second plane making an angle a. We want a rough idea of the extension of the area between the plates by the spreading of the lines of induction beyond the boundary. We know that the actual extension of the area will be greater than we shall calculate it to be if we prescribe an arbitrary distribution of lines of force other than that which is consistent with Laplace's equation.

Assume, then, the lines of force to be segments of circles centre O, and straight lines perpendicular to O A. The induction along a line P Q R will be $\frac{V}{(\pi - a)x + t}$, V being difference of potential between the planes, and the added induction from O P B will be

$$\int_0^x \frac{V\,dx}{(\pi - a)x + t} = \frac{V}{\pi - a} \log \frac{(\pi - a)x + t}{t}.$$

Thus if $a = \frac{\pi}{2}$ we have for $x = t, 2t$, &c.

x	$\frac{1}{\pi - a} \log \frac{(\pi - a)x + t}{t}$		
t	·599	$3t$	1·190
$2t$	·904	$4t$	1·263
		$5t$	1·387
		$10t$	1·792

showing that the extension of the area of the field is likely to be considerable.

(2) The failure of the actual curve to reach the maximum indicated by approximate theory is because the theory assumes that all tubes of induction passing through the magnets pass also through the armature. Familiar observations round the pole pieces of the magnets show that this is not the case. If ν be the ratio of the total induction through the magnets to the induction in the armature we must, in our expression for the line integral of magnetising force, replace the term $f\left(\frac{I}{A_3}\right)$ by $f\left(\frac{\nu}{A_3}\right)$; ν is not strictly a constant, as we shall see later; it is somewhat increased as I increases owing to magnetisation of the core of the armature, and it is also affected by the current in the armature. For our present purpose we treat it as constant.

There is yet another source of error which it is necessary to examine. Some part of the induction in the armature may pass through the shaft instead of through the iron plates. An idea of the amount of this disturbance may be readily obtained. Consider the closed curve ABCDEF, AB and FEDC are drawn along lines of force, AF and BC are orthogonal to lines of force. Since this closed curve has no currents passing through it, the line integral of force around it is *nil*; therefore, neglecting force along ED, we have force along AB is equal to force along FE and DC. In the machine presently described we may safely neglect the induction through the shaft; the error is comparable with the uncertainty as to the value of l_1; but in another machine, with magnets of much greater section, the effect of the shaft would become very sensible when the core is practically saturated.

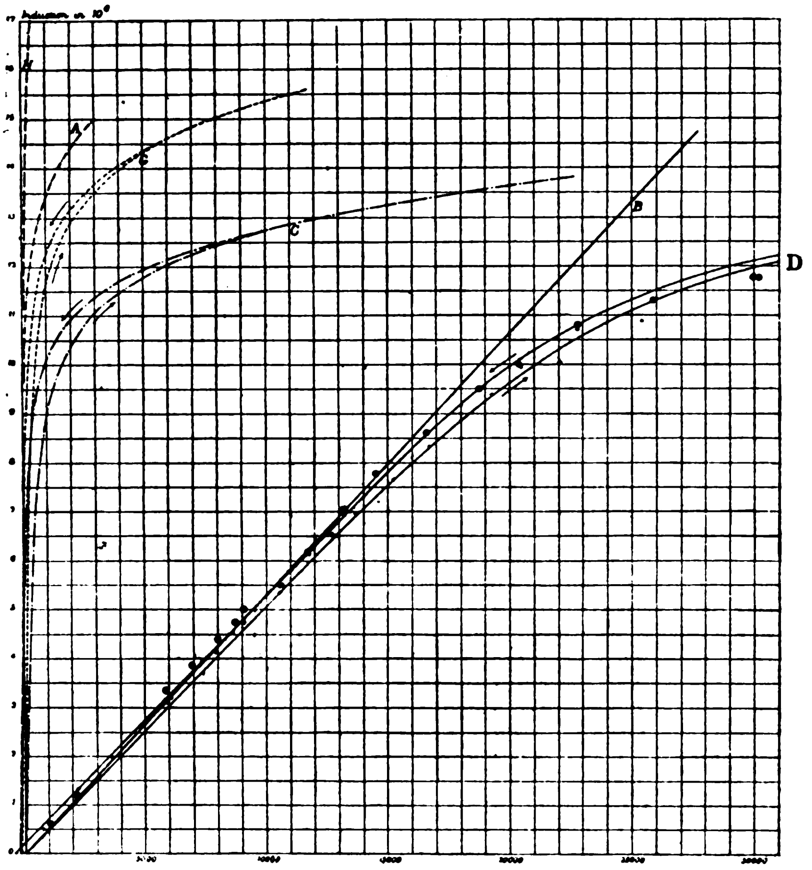

Diagram B.

Correct Synthesis of characteristic curve :—A, armature. B, air space. C, magnets. D, calculated curve. E, observations, + ascending, (+) descending. G, yoke. H, pole pieces.

The amended formula now becomes.

$$4\pi n c = l_1 f\left(\frac{I}{A_1}\right) + 2 l_2 \frac{I}{A_2} + l_3 f\left(\frac{I}{A_3}\right) + l_4 f\left(\frac{\nu I}{A_4}\right) + 2 l_5 f\left(\frac{I}{A_5}\right)$$

where l_4 is the mean length of lines of force in the wrought iron yoke, A_4 the area of the yoke, l_5 and A_5 corresponding quantities for the pole-pieces, the last two terms being introduced for the forces required to magnetise the yoke and the two pole-pieces.

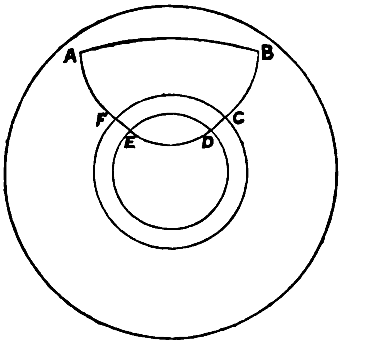

Fig. 2.

We now repeat the graphical method of construction exactly as before, the actual observations of induction in armature and current being plotted on the same diagram, (Diagram B), in which curve G represents the force required to magnetise the yoke, and curve H that required to magnetise the pole-pieces. Before discussing these curves further, and comparing the results with those of actual observation, it may be convenient to describe the machine upon which the experiments have been made, confining the description strictly to so much as is pertinent to our present inquiry.

Description of Machine.

The dynamo has a single magnetic circuit, consisting of two vertical limbs, extended at their lower extremities to form the pole pieces, and having their upper extremities connected by a yoke of rectangular section. Each limb, together with its pole piece, is formed of a single forging of wrought iron. These forgings, as also that for the yoke, are built up of hammered scrap and afterwards carefully annealed, and have a magnetic permeability but little inferior to the best Swedish charcoal iron. The yoke is held to the limbs by two bolts, the surfaces of contact being truly planed. In section the limb is oblong, with the corners rounded in order to facilitate the winding of the magnetising coils. A zinc base, bolted to the bed-plate of the machine, supports the pole pieces.

The magnetising coils are wound directly on the limbs, and consist of 11 layers on each limb of copper wire 2·413 mms. diameter (No. 13, B.W.G.), making 3,260 convolutions in all, the total length being approximately 4,570 metres. The pole-pieces are bored to receive the armature, leaving a gap above and below, subtending an angle of 51 deg. at the centre of the fields. The opposing surfaces of the gap are 8mms. deep.

The following table gives the leading dimensions of the machine :—

	cms.		cms.
Length of magnet limb	=45·7	Distance between centres of limbs	=38·1
Width of magnet limb	=22·1	Depth of pole piece	=25·4
Breadth of magnet limb......	=44·45	Width of pole piece measured parallel to the shaft	=48·3
Length of yoke..................	=61·6	Thickness of zinc base	=12·7
Width of yoke..................	=48·3	Width of gap.....................	=12·7
Depth of yoke	=23 2		
Bore of fields..........	=27·5		

The armature is built up of about 1,000 iron plates, insulated one from another by sheets of paper, and held between two end plates, one of which is secured by a washer shrunk on to the shaft, and the other by a nut and lock-nut screwed on the shaft itself. The plates are cut from sheets of soft iron, having probably about the same magnetic permeability as the magnet cores. The shaft is of Bessemer steel, and is insulated before the plates are threaded on.

The following table gives the leading dimensions of the armature :—

Diameter of core	=24·5	Length of core over the end plates	=50·8
Diameter of internal hole ..	= 7·62	Diameter of shaft	= 6·985

The core is wound longitudinally according to the Hefner von Alteneck principle with 40 convolutions, each consisting of 16 strands of wire 1·753 mm. diameter, the convolutions being placed in two layers of 20 each. The commutator is formed of 40 copper bars, insulated with mica, and the connections to the armature so made that the plane of commutation in the commutator is horizontal, when no current is passing through the armature.

Fig. C, shows a side elevation of the dynamo, Fig. D a cross-section through the centres of the magnets ; Fig. E a section of the core of the armature, in a plane through the axis of the shaft.

The dynamo is intended for a normal output of 105 volts 320 amperes at a speed of 750 revolutions per minute. The resistance of the armature measured between opposite bars of the commutator is 0·009947 ohm, and of the magnet coils 16·93 ohms, both at a temperature of 13·5° centigrade, Lord Rayleigh's determination of the ohm being assumed.

We have now to estimate the lengths and areas required in the synthesis of the characterestic curve.

A_1 ;—from the length of the core of the armature (50·8 cms.) must be deducted 3·4 cms. for the thickness of insulating material between the plates. The resultant area is, on the other hand, as has already been stated, slightly augmented by the presence of the steel shaft. A_1 is taken as 810 sq. cms.

l_1 ; this is assumed to be 13 cms. : *i.e.*, slightly in excess of the shortest distance (12·6) between the pole-pieces.

A_2 ;—the angle subtended by the bored face of the pole-piece at the axis is 129°, the breadth of the pole-piece is 48·3 cms., the diameter of the bore of the field is 27·5 cms., and, as already stated, the diameter of core 25·5 cms., thus, the area of pole-piece is 1,513 sq. cms., and the area of 129° of the cylinder at the mean radius of 13·0 cms. is 1,410 sq. cms. ; this value is taken for A_2 in the curves drawn on diagram

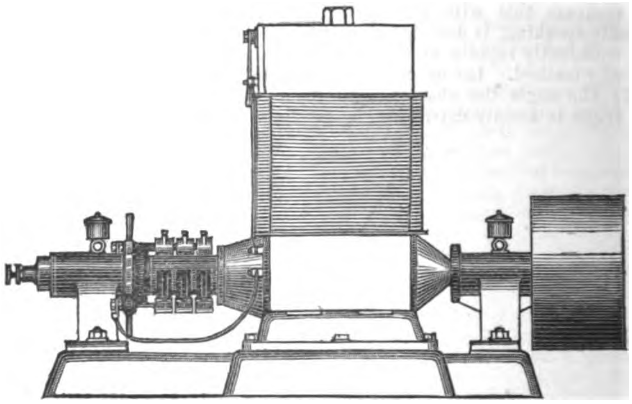

Fig. C.

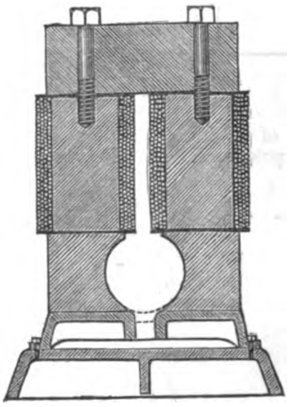

Fig. D.

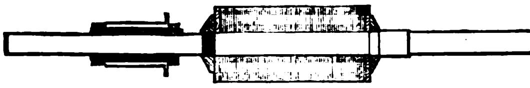

Fig. E.

A. In diagram B, A_2 is taken as 1,600, an allowance of 190 sq. cms. being made for the spreading of the field at the edges of the pole-pieces, or $\frac{190}{160}=1·2$ cm. all round the periphery, that is $\frac{1·2}{1·5}=0·8$ of the distance from iron of pole pieces to iron of core.

l_2 is 1·5 cm.

A_3 is a little uncertain as the forgings are not tooled all over ; it is here taken as 930 sq. cms., but this value may be slightly too high.

l_3 is 91·4 cms.

A_4 is 1,120 sq. cms.

l_4 is 49 cms., being measured along a quadrant from the centre of the magnet, thus :—

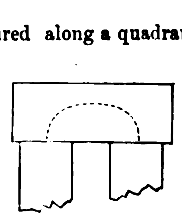

Fig. 3.

A_5 is 1,230 sq. cms., intermediate between the area of magnet and face of pole-piece.

l_5 is 11 cms.

ν was determined by experiment as described below, and its value is taken as 1·32 ; when the magnetising current is more than 5·62 amperes its value should be a little greater.

The function $f(a)$ is taken from Hopkinson, *Phil. Trans.*, Vol. 176 (1885), p. 455 ; the wrought iron there referred to was not procured at the same time as, and its properties may differ to a certain extent from,

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the wrought iron of these magnets. The curves now explain themselves: the abscissæ in each case represent the line integral of magnetising force in the part of the magnetic circuit referred to, the ordinates the number of lines of induction which also pass through the armature. The results of the actual observations on the machine are indicated, those when the magnetising force is increasing +, when it is decreasing (+). The measurements of the currents in the magnets which were separately excited, and of the potential difference between the brushes, the circuit being open, were made with Sir W. Thomson's graded galvanometers, standardised at the time of use. The irregularities of the observations are probably due to the variations of speed, the engine being not quite perfectly governed. The second construction exhibits quite as close an agreement between observation and calculation as could be expected; the deviation at high magnetising forces is probably due to three causes, increase in the value of ν when the core of the armature is partially saturated, uncertainty as to the area A_3, difference in the quality of the iron. It is interesting to see how clearly theory predicts the difference between the ascending and descending curves of a dynamo. Consideration of the diagram proves that this machine is nearly perfect in its magnetic proportions. The core might be diminished by increasing the hole through it to a small, but very small, extent without detriment. Any reduction of area of magnets would be injurious; they might, indeed, be slightly increased with advantage. An increase in the length of the magnets would be very distinctly detrimental. Again, little advantage results from increasing the magnetising force beyond the point at which the permeability of the iron of the magnets begins to rapidly diminish. For iron of the same quality as that of the machine under consideration a magnetising force of $2 \cdot 6 \times 10^3$ or 28·4 per centimetre is suitable. To get the same induction in other parts of the circuit, the diagram shows that for the air space a magnetising force of 21×10^3 is required, for the pole-pieces $0 \cdot 1 \times 10^3$, for the armature $0 \cdot 2 \times 10^3$, for the yoke $0 \cdot 6 \times 10^3$, making a total force required of $24 \cdot 5 \times 10^3$. Any alteration in the length or the area of any portion of the magnetic circuit entails a corresponding alteration in the magnetising forces required for that portion, at once deducible from the diagram. Similar machines must have the magnetising forces proportional to the linear dimensions, and, consequently, if the electromotive force of the machines is the same, the diameter of the wire of the magnet coils must be proportional to the linear dimensions. If the lengths of the several portions of the magnetic circuit remain the same, but the areas are similarly altered, the section of the wire must be altered in proportion to the alteration in the periphery of the section.

(To be continued.)

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

DISCUSSION ON MR. G. KAPP'S PAPER.

(Continued from page 20.)

Mr. MORDEY inquired whether the magnetic effect of the current in the coils of the armature ought not to be taken into consideration in determining the magnetic resistance of the armature core. The current tended to a certain extent to polarise the core in a reverse direction to that of the field-magnets, hence an apparent reduction of magnetic resistance might be expected to ensue. Thus another reason existed for making the cross section of the field-magnets greater than that of the iron in the core, in addition to that pointed out by Mr. Kapp.

Mr. FRICKER inquired whether the specification of the magnetic induction of a given current in a coil ought not to be expressed in "ampere feet" rather than by "ampere turns."

Mr. CROMPTON said that while it remained a regrettable circumstance that more practical experience was being gained in other countries, yet he felt proud of the fact that it was in England the fundamental work both in theory and in practice had been accomplished—a work which rendered it possible for others to obtain advantages which for the present were denied ourselves. Mr. Crompton then referred to M. Deprez, and with reference to his recent claim to have originated the short, thick, field-magnet, said that he was confident that this claim could not be substantiated. Neither did he think that M. Deprez had in reality been the first to use the "characteristic curve," of which Dr. Hopkinson was undoubtedly the originator. Mr. Crompton thought that the progress which had been made in the construction of dynamos during the last four years could only be considered highly satisfactory, in the light of the fact that during that period the cost of manufacture had been reduced to little more than one-fourth for machines of the same output.

Mr. ALEXANDER SIEMENS pointed out the desirability of not running dynamos up to their maximum capacity. A factor of safety was always taken in other machinery, and a similar rule should be observed in regard to dynamos.

Mr. SWINBURNE said that the principal difficulty in the application of the formulæ, both of Mr. Kapp and of Dr. Hopkinson, arose from the necessity of determining the relative magnetic resistance of the air, which was by no means an easy matter. Mr. Swinburne then pointed out further reasons for believing that Prof. Rowland's formula of magnetic induction was inaccurate. If it had been true it would have been impossible to build a self-exciting shunt-wound machine. Mr. Kapp had said that machines with too little iron could not be compounded. On the contrary, a machine with its field section little more than its armature section is very easy to compound. With regard to laminated field-magnets, it was true that Messrs. Crompton and Co. employed bar iron for their field-magnets, not, however, with the idea of avoiding Foucault currents, which in a properly built machine were negligible in the field, but simply from the facility of construction which the use of bar iron afforded.

Mr. ESSON said it would be useful to have data as to the comparative advantage of armatures having cores composed of discs and of wire, other things being equal. Referring to the necessity for making the cross section of the field-magnets greater than that of the armature cores, he would also like to inquire what should be the exact ratio between these quantities. Great divergence existed among different makers in this respect. In the Mather and Platt machines and in the earlier Phœnix machine the cross-sectional area of armature core is to that of the field-magnets as 2 to 3; in Messrs. Crompton's machines and in Mr. Kapp's the ratio is 1 to 2; in Goolden and Trotter's and some others it is as high as 1 to 1. There must, however, be some point of maximum economy. He had recently made an experiment in which by doubling the quantity of iron in the armature the number of lines passing through it had been increased 90 per cent. Since then he had been reducing the relative section of the field-magnets with advantage. The present practice in the Phœnix machine was to employ the ratio 3 to 4, but he could not say whether they should not still further increase the ratio.

PHYSICAL SOCIETY.—Nov. 13.

Prof. BALFOUR STEWART, President, in the chair.

In opening the proceedings the President referred to the great loss which the society had recently sustained by the death of Prof. Guthrie, F.R.S., the founder of the society and his predecessor in the chair. In the capacity of Demonstrator Prof. Guthrie contributed materially to the success of the society's meetings, and his decease is deeply regretted. The President also announced that the council were considering what steps should be taken to commemorate the late Dr. Guthrie, and that a circular expressing their views would be placed before the members in the course of a few days.

The following papers were then read:—

"*On the Peculiar Sunrise Shadows of Adam's Peak in Ceylon.*" By the Hon. RALPH ABERCROMBY, F.R. Met. Soc. The author prefaced his description by an extract from a paper on the same subject by the Rev. R. Abbay, read before the society on 27th May, 1876, in which the explanation proposed is that the effects are caused by total internal reflection, as in ordinary mirage, the difference of air density being in this case due to the low temperature at high altitudes. The author pointed out that Mr. Abbay neglects the difference of density due to elevation, and that his own thermometric observations disprove conclusively any idea of mirage. The chief phenomena observed were, first, the appearance of a circular rainbow with spectral figures near the top of the shadow of the peak, and, second, a peculiar rising of the bow and shadow, which seem to stand up in front of the observers. Both these effects are traced to the existence of mist clouds in the vicinity of the shadow. Two dark rays or brushes were seen to shoot outwards and upwards from the circumference of the bow, in directions nearly coinciding with the prolongations of the edges of the shadow when seen projected on the lower mist clouds, but the author does not attempt to explain this phenomenon. On one occasion a second and outer bow was seen. The times during which the phenomena were visible were too short to permit sextant observations being taken, but the diameter of the inner bow was estimated at 8 deg. or 12 deg. A totally different kind of shadow is sometimes seen from Adam's Peak just before, and at the moment of, sunrise, which seems to stand up against the distant sky. The author found a similar effect at Pike's Peak, Colorado, which is visible only at sunset. Mr. G. Griffiths remarked that he had often seen similar appearances in Switzerland. In answer to questions by the President and Prof. S. P. Thompson, the author said the reason why the shadows are seen from Adam's Peak at sunrise, and Pike's Peak at sunset, was that the configuration of the land on the west side of the former is similar to that on the east side of the latter, both being low, whereas the opposite sides are high, and therefore unsuitable for showing the phenomena. In all cases he believed the appearances were due to the shadows being projected on clouds of suspended matter in the air at various altitudes. He had not noticed whether the colours were reversed in the second bow seen from Adam's Peak, but observed that this bow nearly but not quite touched the inner one.

"*Note on the Internal Capacity of Thermometers.*" By A. W. CLAYDEN, M.A. Read by Prof. Reinold, secretary. The author proposes to determine the volume v of the mercury by measuring the capacity c of a detached piece of the same tube of known length, and thence inferring the volume of t degrees of the thermometer tube, the length of which is equal to that of the piece of tube taken. By assuming the value of a (the coefficient of apparent expansion of mercury in the particular kind of glass) to be known, the volume of the mercury in the thermometer can be calculated, since $c = t\,a\,v$. Prof. Rücker remarked that there were often considerable differences in the sectional area of different parts of the same tube, and hence the method would probably not be very reliable.

On the motion of the President, a vote of condolence to Mrs. Guthrie on her sad bereavement was passed unanimously.

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LEGAL INTELLIGENCE.

The Electric Sun Lamp and Power Co. (Limited) v. Sir Coutts Lindsay and Co. (Limited).

This was an appeal from an order made by the judge in chambers that the defendants should bring into court as a condition to be allowed to defend the action the full sum claimed by the plaintiffs against the defendants, £776. 9s. 8d.

Mr. MOULTON, Q.C., who represented the defendants, explained that the original action was brought against Sir Coutts Lindsay and Co. (Limited), a limited company established for the purpose of supplying electric light installations to the Grosvenor Gallery, Old Bond-street, and neighbourhood, for the full amount contained in five certificates which the plaintiffs alleged were certificates against the defendants for the price of lamps and dynamo machines supplied by the plaintiffs to the defendants. Having read the several documents and the affidavit of the secretary of the plaintiff company, the learned counsel proceeded to argue that this was a case in which the person who swore that affidavit must have consciously kept from the Court most important information with regard to the validity of his claim, and contrived skilfully—he (the learned counsel) would not for a moment say that the secretary had transgressed literally the truth, but had tried to give such a representation as was calculated to deceive the Court. The defence was simply this. The contract was not made with Sir Coutts Lindsay and Co. (Limited), but it was made with Sir Coutts Lindsay personally, and the only connection that the limited company had in the contract was that so far as the dynamos were concerned—the price of which was £475, and in respect of which £237. 10s. was given—was that they agreed with Sir Coutts Lindsay to take them over at the price at which they were supplied by the Company. They had paid £237 already, and they were now perfectly willing to pay into court the other £237, for which they were certainly liable. But they had never had anything to do with the remainder of the contract, which must have been perfectly well known to the plaintiff Company, as the correspondence between the several parties to the action amply testified. He then proceeded to read the letters which had passed between the secretary of the plaintiff company and the defendants, and Sir Coutts Lindsay personally, in support of this contention.

Mr. MANSELL JONES, who appeared for the plaintiffs, maintained, on the other hand, that there was no evidence to show anything in the nature of separate contracts, and that if there was a contract at all, it was indivisible. He submitted that it was an attempt to mix up Sir Coutts Lindsay and Sir Coutts Lindsay and Co. (Limited), to the prejudice of the plaintiffs. What his clients said was that they could not get payment from either one or the other, and that the Company had got the goods at the Grosvenor Gallery, and were carrying on business with these goods, for which they declined to pay the plaintiff company.

On examining the certificates and correspondence bearing on the transactions, the learned judges who heard the case (Mr. Justice A. L. Smith and Mr. Justice Wills) gave judgment in favour of the defendants, deciding that they were liable to pay into court only £237. 10s.

Cook v. The Great Western Railway Company.

On Saturday last, in the High Court of Justice (Chancery Division), before Mr. Justice North, a motion to enforce an injunction, granted in July last, against the Great Western Railway Company, was heard. The plaintiffs were the trustees of the Paddington estate and the tenants of some of the houses near the premises of the Great Western Railway Company, where machinery for the production of electric light, used at the hotel, stations, and premises of that company at and near Paddington, has been in operation for some time past. In July last the Court restrained the company from using the premises comprised in their lease so as to cause a nuisance to the owners or occupiers, or from suffering on any part of the premises works for electric lighting, or other works (except smiths' shops connected with the company's works) which were or might be a nuisance to the trustees, tenants, or occupiers of the Paddington estates, and from maintaining on the premises stationary engines exceeding in the whole 25 horse-power, or which do not consume their own smoke. The operation of the injunction was to be suspended till October 19 last, and the injunction as to the engines was not to be put in operation so long as they did not cause material annoyance.

Mr. H. H. Giffard, Q.C., and Mr. Rashleigh appeared in support of the motion; the Attorney-General (Sir R. Webster, Q.C.), Sir Horace Davey, Q.C., and Mr. R. S. Wright appeared for the company.

Mr. Justice NORTH said that as he understood the argument on the part of the plaintiffs they were absolutely entitled as of right to the immediate issue of a writ of sequestration. He was of opinion that it was a matter for the discretion of the Court whether, though the order for an injunction, as in this case, had not been obeyed, the writ of sequestration should issue or not, or on what terms, if issued or refused, the parties should be put. In his opinion, this was a case in which further time ought to be allowed. The defendants had not in this case contumaciously or wilfully broken the injunction, they had been using their best endeavours to comply with it, and there was evidence that if given two months more they would probably abate the nuisance. He thought it better not to make an order for sequestration and postpone the operation of it, but rather to let the motion stand over till next sittings, which would be in effect giving two months to the defendants. If at the expiration of that time he found the injunction was not complied with, it would take a great deal to induce him not to order the writ to issue.

Notice of appeal was at once lodged against the decision of Mr. Justice North, and the case was again heard yesterday in the Court of Appeal, before Lords Justices Cotton and Fry, the same counsel appearing as before.

The ATTORNEY-GENERAL and Sir HORACE DAVEY exhaustively criticised the evidence that had been given in the affidavits at the trial in July last, to show that the nuisance complained of was much exaggerated. They also contended, as the learned judge pointad out, that the defendants had not been guilty of a wilful violation of the injunction, but on the contrary had used every human means in their power to comply with it, and that probably by the time the two months had passed they would be able to satisfy the inhabitants on the score of the nuisance complained of.

Mr. GIFFARD replied to the arguments brought forward by his learned friends at great length, and pointed out that none of the evidence—even including that of so eminent an authority as Sir Frederick Bramwell—afforded the smallest hope that some means would be found to abate the nuisance within the time. The experiments of the last twelve months had been a long series of failures. It was a hopeless task. If there were three dynamos driven with 600 horse-power engines just behind their lordships, could the evidence, even of an expert witness, that possibly in two months' time some means might be devised for abating the annoyance from those engines after the futile attempts that had been made to do so, have the smallest weight. He ventured to say that if their lordships' sanctuary had been invaded in that way they would not give the two months asked for by the defendants. He submitted that the defendants had been guilty of wilful disobedience, although not in the sense of malicious disobedience to the order of the Court. He thought that to imply that the evidence which had been forthcoming from so many independent sources was exaggerated in the absence of cross-examination was a suggestion which their lordships would not listen to. Let their lordships consider the consequence of refusing the plaintiffs the injunction they asked. It would mean that they would have to continue under an infliction which no subject of this realm, but least of all a subject who had been protected by an order of the Court, ought to be compelled to endure.

The Court then rose, judgment being deferred until this (Friday) morning.

COMPANIES' MEETINGS.

West Indian and Panama Telegraph Company (Limited).

The nineteenth ordinary general meeting of the members of this Company was held at Winchester House, 50, Old Broad-street, on the 17th inst., under the presidency of C. W. Earle, Esq.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting, and the minutes of the last meeting, which were approved by the present meeting, and signed as correct by the Chairman. The report of the Directors was taken as read.

The CHAIRMAN: On the last occasion when we met to discuss our affairs I introduced the question of the report by the remark that we were suffering under the depressing influence of declining traffics. That depressing influence has not passed away, and anybody who watches the sugar market will see very good reason why it does not pass away, and would be very much surprised if it did. Sugar which in the first years of this decade averaged about 20s. to 21s. per cwt. is now selling at something under 11s. per cwt., and when we last met the average price was about 13s. Sugar, therefore, has declined from what we may call the normal price of the brand of sugar—Muscavado—very nearly 50 per cent. since the days when we were rather more prosperous than we are now. Not only have the West Indian Colonies suffered that great fall in the price of their principal product, but some of them were visited during the last summer by convulsions of nature which have had very disastrous effects upon them. Jamaica has been twice swept by a hurricane, and a great deal of destruction has occurred there, and St. Vincent was visited by a tornado on the 16th of August last, which, in the words of the Governor in his late address to the Legislative Council, it would be impossible for anyone to forget who had witnessed its devastating effects. This disaster at St. Vincent, coming upon a long period of depression in the sugar trade, has forced them to reconsider their expenditure—their Budget—and I am sorry we received a telegram the day before yesterday, announcing that one of the reductions they had made was in our subsidy, reducing it (temporarily I hope, though the telegram does not say so) from £800 to £400 a year. Until we get the documents, detailing the communication from the colony (this is merely a telegraphic message sent by our own people) we shall not know how to deal with it; but it is to be feared that absolute necessity has made them reduce it. Whether they have reduced us in equitable proportion with their own charges remains to be seen when the details come more fully to our notice. The account that we tender you today as the effect of the reduction of the traffic which is announced in our report offers no subject for remark. I shall be very happy to answer any question that may be put, but the expenditure side of the account is almost identically the same as it usually is as far as it is controlled by us. There is a saving of about £1,400 compared with the corresponding period; but that saving arises entirely from items in Abstract C which refers to the repair and renewal of the cables, and which is always a varying item, and one which it is impossible for us to control. It depends so entirely upon the work which the ships have to do, the luck they have in doing it, and the losses in their grappling ropes, and a variety of other causes which make that Abstract C a very varying item. As to our cable repairs, the principal cable operations we have had to deal with in the half year are referred to in the report. You may remember last half year that the original line

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between Jamaica and Porto Rico, which we had repaired, became inoperative, and we decided then to grapple for it to get it where we could upon each side of the break, and lay in a new piece of cable of considerable length, but in shallower water, the water being so deep where the original cable was laid that it was impossible to recover it. Therefore we had to lay in a considerable portion of new line. While that operation was being conducted we had a break in the Colon cable, and the ship being in communication with Porto Rico we immediately instructed it to go to the repair of that cable, which was then rather important as earning money. She repaired one break and found there was another, and she has now been some time on that operation. She has recovered the Colon end and has spoken to Colon, but since then we have heard nothing more. It is satisfactory to find that she lifted that cable in considerable depths, and it appears, as far as we have heard, to be in good, strong condition, though it has been down about 15 years (hear, hear). I may mention (perhaps I ought to have mentioned this while talking about the account) that the debenture debt of £50,000 falls due on the 31st Dec. next, and we intend to propose to the holders of these debentures to extend the time upon an interest of 5 per cent. If there are any holders of debentures who prefer not taking 5 per cent. we shall be able to transfer them [hear, hear]. We shall arrange for it. The security of the Company has so much improved owing to our reserve fund and the accumulation we have made that we think it will be a very good investment at 5 per cent. I shall renew mine, and if any debenture holders are here they will perhaps communicate with the secretary if their names are not known to him already. There is one point in our report which is an element of considerable satisfaction—that is, the abandonment of the proposed Bermuda-Jamaica cable. That would have been, I am afraid, a very injurious cable for us. It would have brought competition into the midst of our system, competing under a Government guarantee, and it is highly satisfactory to have the information from the Secretary of State that the idea, for the present, at all events, is abandoned. I hope, seeing that Jamaica is connected by three cables with the rest of the world, and that a strategical cable of that sort—for it is purely strategical, and in case of a great war, when it would only be of any importance, it would be sure to be cut—I hope that the Government will save their money and ours by not going into the business at all. I think I have touched upon all the points that occur to me to refer to. I shall be very happy to answer any questions. The outlook in the West Indies is not at this moment encouraging, but we must hope when things change (as for instance by a change of products—for if sugar is to depart they may find some other means for cultivating their very fertile soil) that there will be some return of prosperity both for them and us. I now beg to propose that the Directors' report and accounts to the 30th June, 1886, submitted to this meeting be and the same are hereby received and adopted, and that, as recommended by the Board, a payment of 8s. per share on account of arrears of dividend on the first preference shares be and the same is hereby declared.

Mr. W. FORD seconded the motion.

Mr. W. GRIFFITH said he thought the report was one that must commend itself to the Company at large, and the statement they had listened to from the Chairman also, he thought, corroborated the hope which the report was calculated to excite. It was something to be informed that their security was so good that they might expect now to change a 6 per cent. debenture debt into one bearing 5 per cent., and considering that all parts of the world had been suffering from a depression of trade they must say it was satisfactory that they had so far kept up their business. He had been struck with certain expenses appearing in Abstract C. The Cuba Company, whenever they had any cable laid down, made terms with the manufacturer to keep it in repair for a certain number of years. That arrangement saved the Directors a great deal of anxiety, and enabled them also to withhold a portion of the capital which was paid to the manufacturers year by year instead of in one large sum. He admitted there might be some difficulty in applying such a principle to the case of this Company, which had so many stations, but he suggested it for the consideration of the Directors.

Mr. MORTEN said that the total receipts for the Christmas half year were £38,000, and for the June half year £45,400. The interest on their investments and so on had returned them £4,100 for the year, so that their total income for the last year was £87,500, the total expenditure for the year having been £49,600. Deducting that from the total they had a net profit of £38,000. The current interest on the first preference shares was £20,700, and on the second preference shares £2,800, making a total interest of £23,500. He had included in the expenses the debenture interest. They were thus left with a total balance after paying preference shares interest of £14,500. That would give 3s. a share to the ordinary shares. The reserve fund was £122,800, plus the improved value of the securities of £5,300. There was nearly a profit of £6,000 on the investments forming the reserve fund, which must be taken to amount to at least £129,000. Further, they were replacing their cables not out of the reserve fund, but out of the current earnings. The Company was on a splendid commercial footing. He held that they could easily raise £100,000 by debentures at 4½ per cent., and they could then pay off the existing debenture debt and the arrears of dividend on the preference shares, and start afresh, paying a dividend on the ordinary shares, and going on building up the reserve fund. They must either be in a very poor position, in which case they ought not to pay £2,100 a year for Directors' fees, or else they were in a very good position, in which case the shareholders ought to be sharing in the benefits.

Mr. GUESDON said, with regard to the remarks which they had just heard, the course which the Company had adopted might not be agreeable to the ordinary shareholders. He himself held the three classes of securities; and, therefore, he thought he was able to give an unbiassed opinion. The Directors, in his opinion, had acted wisely in forming the reserve fund. Mr. Griffith had spoken about a guarantee which had been given to another company by the company that made its cables. *Apropos* of that matter, he was very pleased to see the name of another company mentioned in the Directors' report, and they had entered into a contract with Henley's Telegraph Works Company for the manufacture of the cable. He thought, but he did not say it was so in this Company, that the industry of manufacturing cables had been very much stifled, as that was one of the powers which could be exercised by the great companies. As to the value of the ships, he did not know whether they insured for the whole cost of the ships or whether they insured against total loss. He advised them to insure against total loss, when the matter would be made more clear, and they would be paying a smaller premium.

The CHAIRMAN said that their idea in regard to the insurance of the ships was that they should have the money for the ship in the event of its loss.

Sir JAMES ANDERSON pointed out that the Company did not possess enough yet to replace the ships.

Mr. GUESDON referred to the issue of proxies, and regretted that the Directors had persisted in issuing them in face of the injunction. If they were to be issued, they ought to be issued in blank form.

The CHAIRMAN pointed out that it was not in connection with *bonâ fide* shareholders that the Directors issued proxies, but against "bears" and wreckers, who might come to their meetings, and injure the Company, unless they took the precaution of sending out proxies, which, however, on the present occasion had been sent at the expense of the Directors.

Mr. GUESDON wished to know what services Mr. Cyrus Field rendered to the Company that he should be one of the Directors.

The CHAIRMAN said that they were bound by the original agreement to have Mr. Field on the Board, and that that gentleman rendered them valuable assistance. The Company had constant relations with American companies through whose lines they worked, and there were frequent subjects to which Mr. Field attended on the other side.

Mr. GUESDON said that he noticed in the case of another Company a very satisfactory feature, namely, that the Directors, owing to the great depression that existed, had reduced their fees, and it seemed to him that as this Company had a considerable falling off in revenue, the Directors might follow that example. If the Directors attended a meeting once a week that meeting cost the Company £40.

The CHAIRMAN replied that the Directors' attendance at meetings was only one item in connection with their work.

Mr. GUESDON said he would not move any resolution on the subject, but it would be acceptable if the Directors consented to reduce the amount they took for their fees. He had no hesitation in expressing his confidence in the Board.

Mr. JOHN NEWTON said he was very pleased to see that the policy of the Directors was freely criticised. As to the reserve fund, he could not conceive how anyone could ignore a part of his property, and say that the interest from that property was not his income. The money they derived from the investment of their reserve fund ought to go to the credit of their annual revenue, and when they wished to add anything to the reserve fund let the total sum be shown. He thought the Directors were perfectly right in issuing proxies at their own expense, but it would be altogether *ultra vires* for them to issue proxies now at the expense of the Company. It was perfectly legitimate for shareholders to move resolutions at a meeting, as he himself had done, in order to get an expression of opinion, but it was not right for any shareholder to have the power of upsetting the Company.

Mr. WM. ABBOTT thought it exceedingly gratifying that the Company occupied the strong position it did, and the Directors were to be commended for the manner in which they had conducted its affairs to such a successful result. The Chairman had used the word "wrecker," and he (the speaker) could speak with some experience on that point, as he had wrecked the Company himself.

The CHAIRMAN: You did not wreck the Company.

Mr. ABBOTT said he succeeded in wrecking the late Board, and the present Board was the result of the chaos which at that time he created. It was only right, therefore, that he should be present at the meeting to express his satisfaction at the position which the Company now occupied, owing to the exertions of Directors for whose appointment he was in a great measure responsible. He agreed with one speaker that the property of the Company in the market was in a lamentable position. It was lamentable that the whole £883,000 of ordinary share capital was now selling at something less than £80,000, but when they considered the financial strength of the Company, he thought it was something to have attained. A gentleman had called attention to the paltry matter of Directors' fees, but it should be remembered that by their judicious selection of investments for the reserve fund, the Company had benefited by some £6,000 a year. He spoke of the great services which they had rendered to the West Indian Colonies, and thought the sacrifice they made was far more than the subsidies they received were worth.

Mr. MULLENS said he considered that only a portion of the debentures ought to be extended at 5 per cent., and that the other portion should be paid off out of the reserve fund. They were paying 5 per cent. for their debentures, and on their investments they only got 3½ per cent.

The CHAIRMAN, in reply, said with regard to Mr. Griffith's remark about the arrangement made by the Cuba Company, the position was quite exceptional. He very much doubted if they could get any contractor to take the risk of keeping in repair a cable on the other side of the world, and if they could he would make such a charge that it would be outside the power of the Company to bear. The present Board had laid no contractors' cable. They had bought their own cable, and sent it out by their own, or by a hired ship, thus getting rid of all contracts, and doing things very much more cheaply than his experience told him that manu-

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facturing companies would charge. Mr. Guesdon made some remarks about separating the items of messages and subsidies. He thought there would be disadvantages in that. As to the insurance of their ships they had always gone on the principle that if they lost a ship they ought to be able to recover the money that would replace it. In connection with this matter they had acted on a suggestion made by Mr. Guesdon at a former meeting. They had reduced the value of their ships, but they would look into the question again. Mr. Newton had made some remark as to dealing with their investments. He confessed that he did not see that there was much difference in the system. Mr. J. G. Griffiths advised them on that matter, and the Directors framed their accounts on that gentleman's guidance and suggestion as to the details and the technical part. It seemed to him that it was pretty clearly stated what the interest was that was carried to the general year's interest on the investments, and the sum they added as well.

Mr. NEWTON said that the shareholders ought to see one lump sum carried to the reserve fund, and that then each half-year they should see the exact sum added to it. A sum of money should not be credited to a reserve fund on the reserve account as interest on the investment, but the total amount added to the reserve should be clearly stated in the profit and loss account.

The CHAIRMAN said that the point raised was one upon which "doctors differed."

Mr. J. G. GRIFFITHS (the auditor) said that the reserve fund was in fact an insurance fund, and as all funds should be dealt with the revenue from that fund should go to the insurance. It belonged to it, and had nothing to do with the ordinary income of the Company.

Mr. WEAVER said that if they put the interest to the general revenue and divided it they would only have to put more to the reserve fund.

The CHAIRMAN said that with regard to the suggestion of paying off part of the debentures, that went to the whole question as to whether the reserve fund was in excess of what it ought to be. If they said that they would only renew half the debenture debt and pay off the other half, they would reduce the reserve fund by £25,000, and, according to their calculations, they would have to build up the reserve fund again more rapidly.

Mr. GUESDON said that sooner than see the reserve fund interfered with he would advocate the adoption of a bold course, and urge them not to insure their ships. If they ran them successfully for a few years they would be greatly benefited.

Sir JAMES ANDERSON: Suppose you did not? Suppose you ran into another ship?

Mr. GUESDON said that the running down clauses were only £8 a ton.

The CHAIRMAN put the motion, which he declared carried, with one dissentient.

Mr. MORTEN then proposed the following resolution: "That it be recommended to the Board that, inasmuch as this Company is possessed of investments of the value of about £117,000, returning under 4 per cent. interest, the present debentures of £50,000 be not extended at 5 per cent., and that the Directors be earnestly requested to take steps to pay off the arrears of preference interest, and start the Company on a better commercial basis."

A SHAREHOLDER seconded the motion.

Mr. GUESDON moved as an amendment "That all matters relating to the extension of debentures and arrears of interest be left in the hands of the Board."

Mr. WILLIAM ABBOTT seconded the amendment.

The CHAIRMAN put it, and declared that only two had voted against it. He therefore declared the amendment carried, and intimated that that closed the business.

Mr. ABBOTT proposed a vote of thanks to the Chairman and Directors for the way in which they had administered the Company's affairs during the half year. He could not, he said, keep his eyes off the reserve fund, which he thought the Company was very fortunate in possessing.

Mr. PARSEY seconded the motion, and

The CHAIRMAN having acknowledged the compliment, the proceedings terminated.

The Pilsen Joel and General Electric Light Company (Limited).

An extraordinary general meeting of this Company was held on Wednesday at the Cannon-street Hotel, Sir Rawson Rawson in the chair.

Mr. W. H. TRENTHAM (the Secretary) having read the notice convening the meeting,

The CHAIRMAN said: I do not know that it is necessary for me to do more than repeat what I said before, that the object of this meeting is to reduce our capital, to wipe off what we have lost and what there is no immediate hope of recovering, but which will not prevent us from making as large a dividend in future as if this dead weight remained on the books against us. It will enable us as we make profits to declare a dividend to our shareholders. It was passed unanimously, after some discussion, at the last meeting, and I hope it will meet with your favour on the present occasion. I beg to propose: "That if an order of the Court be obtained for confirming this resolution the capital of the Company be reduced by cancelling the sum of £1 per share on the 28,000 shares of the Company of £3 each with £2. 5s. each called up thereon, and the sum of £1. 15s. per share on the 100 fully paid-up shares of £4 each, as being capital which has been lost, or is unrepresented by available assets, and that the Memorandum of Association of the Company be modified so as to carry into effect this resolution."

Mr. WHATELY seconded the resolution, which was carried unanimously.

The CHAIRMAN: I hope as soon as we can get the Court to move in the matter, we shall call a general meeting and lay our year's account before you, which I trust will meet with your approval.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Nov. 17.		Business Done Week Ending Nov. 17. Highest.	Lowest.	
Anglo-American	37,	38	38	37	
Do. Preferred	59,	60	61½	59½	
Do. Deferred	15,	16	16⅜	15⅞	
Brazilian Submarine	10⅞,	11⅛	11⅛	10⅞	xd.
Cuba	11½,	12	11 9-16	—	
Do. Preference	18,	19	—	—	
Direct Spanish	1½,	2	—	—	
Do. Preference	8½,	9½	—	—	
Direct United States Cable	9⅛,	9⅜	9⅜	—	
Eastern Telegraph	10⅜,	10⅝	10 9-16	10⅜	
Do. 6 per Cent. Preference	14¼,	14¾	14½	—	
Do. 5 per Cent. Debentures, 1899	106,	109	107½	107	
Eastern Extension	11⅛,	11⅜	11¼	11	
German Union	9¼,	9¾	—	—	
Globe Telegraph and Trust	5¾,	6	6	5¾	
Do. Preference	12⅜,	12⅞	12¾	12⅝	
Great Northern	13¼,	13¾	13½	13⅜	
Indo-European	34½,	35½	—	—	
Reuter's	7¼,	7¾	—	—	
Submarine	195,	205	—	—	
West India and Panama	⅝,	⅞	13-16	—	
Do. 1st Preference	8¾,	9¼	9	8⅞	
Western Brazilian	6¾,	7	6 15-16	6 13-16	
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—	
Do. 6 per Cent. Sterling Bonds	101,	103	—	—	

TELEPHONES.

Companies.	Closing Prices.		Highest.	Lowest.	
Consolid. Telephone and Maintenance	⅜,	⅞	—	—	xd.
Oriental	3-16	5-16	¼	—	
United Telephone	14¼,	14¾	14 9-16	14½	

ELECTRIC LIGHT.

Companies.	Closing Prices.		Highest.	Lowest.
Anglo-American Brush Light (£3 paid)	2½,	3	2½	—
Do. (fully paid)	4¼,	4¾	—	—
Swan	1⅛,	1⅜	—	—
Maxim Weston	¼,	⅜	⅜	5-16

MISCELLANEOUS.

Companies.	Closing Prices.		Highest.	Lowest.
Telegraph Construction	39	40	40	39½
India Rubber, Gutta Percha, and Telegraph Works	24½	25½	25⅜	24½

TRAFFIC RECEIPTS FOR OCTOBER, 1886.

Companies.	Oct., 1886.	Oct., 1885.	Increase.	Decrease.
Cuba Submarine	2,400	2,156	244	—
Direct Spanish Telegraph	2,013	1,756	257	—
Eastern Extension	37,185	43,986	—	6,801
Eastern Telegraph	49,374	56,994	—	7,620
Great Northern	22,240	—	—	—
West Coast of America	4,285	—	—	—

THE EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY, LIMITED.

NOTICE IS HEREBY GIVEN that in conformity with the conditions contained in the Debentures of the above Company, the following FIVE PER CENT. MORTGAGE DEBENTURES for payment at par, on the 1st January, 1887, at the Banking House of Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C., when the Interest thereon will cease, were this day drawn at the Offices of the said Company, at Winchester House, No. 50, Old Broad-street, in the City of London, in the presence of Sir James Anderson, one of the Directors, George Draper, Esq., Secretary of the said Company, and the undersigned Notary Public.

NUMBERS OF DEBENTURES DRAWN THIS DAY.

58	632	1523	2130	2760	3358	3801	4331	4845	5234
103	634	1525	2131	2808	3406	3816	4347	4859	5251
105	660	1533	2155	2846	3409	3860	4364	4899	5255
106	685	1534	2160	2849	3416	3880	4377	4905	5283
119	797	1563	2165	2955	3428	3906	4390	4971	5289
149	823	1580	2175	2956	3448	3934	4393	4976	5302
182	830	1584	2229	3012	3450	3994	4451	4993	5310
218	857	1596	2237	3054	3473	3995	4458	5031	5362
219	957	1599	2302	3072	3478	4031	4463	5035	5413
221	958	1613	2353	3079	3502	4065	4518	5038	5498
271	1093	1622	2377	3119	3564	4087	4540	5058	5507
272	1095	1792	2421	3129	3580	4088	4545	5061	5512
312	1165	1801	2446	3130	3588	4097	4547	5069	5553
314	1177	1817	2461	3173	3613	4100	4553	5090	5616
315	1245	1820	2499	3177	3619	4113	4564	5092	5671
328	1252	1827	2505	3181	3693	4128	4585	5122	5690
329	1289	1830	2544	3203	3703	4195	4593	5144	5721
372	1295	1882	2571	3223	3711	4202	4595	5159	5734
483	1363	1884	2583	3249	3735	4231	4658	5173	5762
499	1367	1956	2594	3254	3765	4257	4706	5177	5764
509	1473	1967	2622	3261	3766	4260	4712	5202	5839
528	1485	2012	2619	3309	3775	4298	4778	5203	5872
548	1488	2071	2651	3326	3791	4308	4791	5219	5916
590	1489	2097	2692	3345	3795	4313	4794	5223	5931
591	1512	2098	2694						

244 Debentures for £100 sterling each, £24,400

Countersigned:
W. E. VENN,
2, Pope's Head Alley, Cornhill, E.C.,
Notary Public.

GEORGE DRAPER,
Secretary.

London, 16th November, 1886.

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NOTES.

TELEGRAPH CABLE REPAIRED.—The cable between San Juan del Sur and Panama is repaired.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended the 19th inst. amounted to £5,246.

THURSDAY ISLAND CABLE.—We are informed that this cable has been successfully laid by the Eastern Extension Company for the Queensland Government.

ESTIMATES REQUIRED.—We would call the attention of electric light contractors to an advertisement, which appears in another column, asking for estimates for lighting a number of offices in the City.

FOULING A CABLE.—The United States schooner "Grampus," while attempting to weigh anchor, recently fouled one of the Atlantic cables near Jeffrey's Ledge, and was obliged to cut her hawser. No damage was done to the cable.

LIGHTING OF THE RIVER PLATE BANK.—It has been decided to introduce the electric light into this bank, and the work has been put into the hands of Messrs. Drake and Gorham, of 2, Prince's Mansions, Victoria-street, S.W.

SPANISH TENDERS.—Tenders are invited for the 15th of December for the supply of 20,000 insulators for the service of the State Telegraphs. The conditions are on view at the offices of the General Board of Posts and Telegraphs, Madrid.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended Nov. 19 were £4,290, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

"LIVES OF THE ELECTRICIANS."—Messrs. Bell and Son, of Covent Garden, are about to publish a series of volumes under the above title. The first number—which is to be ready next week—is written by Mr. W. T. Jeans, and contains biographies of Prof. Tyndall and Messrs. Wheatstone and Morse.

TENDERS WANTED.—The North-Eastern Railway Company are inviting tenders for the supply of telegraph apparatus, wire and line stores. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York, and must be returned by December 1st to Mr. C. N. Wilkinson, secretary, York.

SOUTH WALES UNIVERSITY COLLEGE.—We have received a copy of the calendar of the University College of South Wales. The Physical Section of this college is under the direction of the Principal, Prof. Viriamu Jones, M.A., B.Sc., assisted by Mr. W. P. Hensley, B.A. A course of electrical engineering is provided, and the laboratory contains a gas engine and dynamo machines.

THE ATTEMPTED BETTING FRAUD.—The case of Myer Myers, who was charged with attempting to corrupt the servants of the Exchange Telegraph Company, for the purpose of fraudulent betting, will not be proceeded with, his counsel (Mr. Kisch) having announced in court on Tuesday that the accused had inadvertently taken an overdose of laudanum, and died on the preceding Thursday.

APPEAL CASE.—Gilman *v.* the Gülcher Electric Light and Power Company.—This appeal, on the part of the plaintiff, from the judgment of Mr. Justice Grantham, who disallowed his claims for fees as director of the defendant company, in respect of the period from 31st December, 1884, to the 14th May, 1885, is to be heard to-day (Friday), before the Master of the Rolls, Lord Justice Lindley, and Lord Justice Lopes.

THE BARTHOLDI STATUE.—The present arrangements for lighting the statue of Liberty are generally acknowledged to be a failure, and Mr. Goff, the President of the American Electric Manufacturing Company, by whom the installation was supplied, has therefore offered to light the statue at his own expense for the present on condition of being permitted to experiment as he pleases as to the best disposition of the lights.

EXHIBITION AWARDS.—Messrs. Marshall, Sons and Co. the well-known engineers, of Gainsborough, were awarded a gold medal at the recent International Exhibition at Liverpool, where they supplied the whole of the motive power for the electric lighting. The same firm obtained a grand diploma of honour at the Edinburgh Exhibition, and have also been awarded prizes at Czernowitz, Austria, and at Gorinchem, Holland.

AUSTRALIA.—A conference is being held at Melbourne between the Postmasters-General of several of the Australian Colonies, and among other questions the delegates are expected to take up is that relating to cable communication and cheap rates. The question is a large one, but is becoming of the utmost importance. It involves the consideration of a general system of guarantees, with the tariff rates controlled by the guarantors.

THE AMERICAN TELEPHONIC LITIGATION.—"It seems probable," says the New York *Electrical Review*, "that the great telephone litigation of the past several years will be concluded during 1887. The Supreme Court of the United States on Monday granted a motion made last week to advance and hear together the telephone cases—six in number—now entered, and ordered that they be set for argument as one case on January 24th, at the head of the calendar."

PERSONAL.—Dr. R. Mullineux Walmsley, senior demonstrator at the Finsbury Technical College in the department of Applied Physics and Electrical Engineering, has been appointed Principal of the Sind State-Aided Technical College, which is now being established at Kurrachee. Dr. Walmsley's numerous friends, while congratulating him on his appointment to so interesting and important a post, will feel much regret that it involves his leaving this country.

SUICIDE BY TELEPHONE.—According to the *Figaro*, a young lady committed suicide at Brussels the other day, under very extraordinary circumstances. Having heard of the unfaithfulness of her lover, she called him up at his place of business by telephone, and asked him if it was true that he was going to marry Mdlle. ——— ? He replied that it was quite true. "Then good bye, for ever," were the next words that reached his ears, followed by the report of a pistol. The poor girl had shot herself.

PRINTING BY ELECTRICITY.—The *American Inventor* of Cincinnati, a large monthly journal, says:—"We print this month's issue for the first time by means of electricity. This is the first plant of the kind in this State. We are running four presses with a single Sprague motor, and find it an immense advance on any other kind of power. The expense for repairs to the motor cannot amount to 10 per cent. of that required for either steam, gas, or water hot air engines, and we see no reason why it will not give for many years to come as good results as at present."

ELECTRIC LIGHT AND VEGETATION.—In the neighbourhood of the tower lights, with which so many of the American cities are now illuminated, the influence of the arc light upon vegetation is becoming very noticeable. A gentleman in Davenport, Iowa, whose garden is within 100ft. of an electric light tower, says that his lilies, which ordinarily close their

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petals long before sunset, now again unfold a few minutes after the lamps commence to burn. It is also observed that the foliage of the trees in Detroit was more luxuriant this summer where the light has fallen on them.

Electric Light in Mines.—At the meeting of the South Wales Institute of Engineers, Cardiff, on Tuesday last, Mr. Hann, one of the managers of the Powell-Duffryn Collieries, described the method patented by him for lighting miners' lamps by means of electricity so as to avoid there ever being a naked light in the mines. The current is supplied by accumulators "of such low power that they may be placed anywhere in the mine with safety." Mr. Mordey also read a paper on the electric lighting of mines, one of the features of his scheme being to surround incandescent lamps with water.

The Fire at Hampton Court Palace.—After the calamitous fire in this palace in 1882, H.M. Office of Works decided to have all the residential apartments in the palace provided with electric appliances, and Mr. Zimdars, of Hatton Garden, was instructed to provide and fix his electric bell system with duplicate indicators and about 80 separate night-alarm bell pushes communicating with the fire brigade engineer's residence, and also with the office of the clerk of the works. The disastrous outbreak which has just occurred would very probably have proved even more calamitous had not these precautions been taken.

A Costly Installation.—The Hotel de Ville at Vienna possesses an installation of 564 16 candle-power lamps, and a few of 30 candle-power. According to some figures given at the recent meeting of the gas engineers of Austro-Hungary the first cost of this installation amounted to very nearly £6,000, while the cost of working, including interest and depreciation at 10 per cent., exceeded £1,300 per annum. The number of lamp-hours is not ascertainable, but it appears that the total number of hours of working is only about 170 per annum, while on many evenings only 20 or 30 lamps are actually in use. The dynamos employed were built by M. Egger, who also has charge of the installation.

Village Lighting in Holland.—The small village of Kinderjik, in Holland, possesses a central lighting station of a somewhat remarkable character. The place was once lit by gas, but owing to the extreme dampness of the soil the pipes rusted away with such rapidity that the works were actually abandoned from this cause. The engine house stands upon piles, and is surrounded by water. A 400 light Edison plant has been put in, and is running with perfect satisfaction. The service is remarkably cheap, varying from about 10s. 6d. per annum for one 16 candle-power lamp to about 9s. each per annum for 20 lamps; the lighting ceases at 12 p.m. It is found that the lamps are taken by villagers, whose earnings do not amount to more than 4s. per day. The capital invested is said to be only about £600, and the company are not allowed to pay more than 5 per cent. per annum. With regard to the rusting of iron, it may be mentioned that the same difficulties have been experienced by the gas companies in the neighbourhood of the salt lakes upon the plains of Mexico.

Junior Engineering Society.—At the last meeting of this society a paper was read by F. Harman Lewis, Stud. Inst. C.E., on "The Electrical Government of the Steam Engine." The author having indicated the particular necessities for, and requirements of, steam engine governors, proceeded to show as an illustration of the importance of perfect regulation how great was the demand for accurate and sensitive regulation of speed in dynamos, and pointed out the various respects in which the centrifugal governor had failed to comply with this demand. Electrical devices for governing the speed of dynamo machinery motors were then considered, and Jamieson's, Richardson's, and Willans' electrical governors were described, the author claiming for the latter certain advantages which the others did not possess, the most noticeable being its great freedom from friction. From certain tests of the efficiency of this governor it appeared that, although the current ranged from 230 to 500 amperes and the boiler pressure from 85lb. to 105lb. per square inch, the electromotive force varied only ·5 volt, these figures being obtained from readings taken at the installation at Victoria Station. The paper was illustrated by some excellent wall diagrams, and a specimen of the Willans electrical governor, kindly lent by its inventor.

Central Lighting Station for Sheffield.—From the *Sheffield Daily Telegraph*, of 20th November, we take the following:—"An electric light supply station, on a large scale, has just been completed by Messrs. Tasker, Sons, and Co., electrical engineers, with the object of supplying light to public buildings, hotels, shops, works, &c., in any part of Sheffield. It is clear, from an inspection of the station, which is enclosed within substantial buildings, in Commercial-street, that preparations have been made for considerable future development and demand for this system of lighting. First, there has been fixed a compound condensing engine of 200 indicated horse-power. Supplying this engine with steam is a large Galloway boiler, fitted with Proctor's mechanical stoker and other improvements. The fly-wheel of the engine works on to counter shafting, and from this the power for the dynamo is taken. At present in the dynamo room are fixed a Thomson-Houston 45-light machine and one Siemens shunt-wound machine, which latter will be employed to charge secondary batteries for incandescent lighting. It is proposed to rent out lights to consumers for an annual sum per lamp, which will include maintenance and attention, thus relieving customers from all trouble in this respect, and already a very encouraging start has been made in the supply of lights to various consumers."

National Telephone Company's Conversazione.—The annual *conversazione* of the *employés* of the National Telephone Company took place on Saturday in the St. Andrew's Hall, Glasgow, a numerous company being present. During the evening the chairman of the company, Colonel R. Rainsford Jackson, delivered an interesting address on the progress the telephone was making in the public estimation. Five and a-half years ago, he said, there were only 317 subscribers in the Glasgow district, whereas they now had no fewer than 1,857, while the company at present had 137 offices, as against 33 five and a-half years ago. At that period, too, the total number of messages sent in a year was 688,000, while it had now reached the high total of 5,020,000. He might add that he considered the telephone service in Glasgow was as perfect as it could be. Sir Wm. Thomson also spoke, and referred to the incredulity with which the announcement of the invention of the telephone had been received, and gave an instructive little sketch of the first experiments made with the instrument. At one of these meetings of scientists in America, at which he had the privilege of b ing present, the first message sent over the wires was, "To be or not to be—that is the question" [laughter.] No doubt they would agree with him that the question had been sufficiently answered. He wished to give his testimony to the efficiency of the Glasgow staff.

The Electric Light at Ingestre Church.—A special service was held in Ingestre Church on Saturday night to celebrate the lighting of the church by electricity, a work which has been carried out entirely at the cost of Lord Shrewsbury. The chancel had been tastefully decorated with flowers

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and plants, and there was a large congregation, which included many of the clergy from the neighbouring parishes. The church, one of Sir Christopher Wren's works, although comparatively small, contains some specially good examples of carved oak; and the rood screen, pulpit, and reading-desk are worthy of special attention. It is situated immediately adjacent to the residence of Lord Shrewsbury, and the current for the electric light is derived from the same plant which supplies the mansion. This plant is capable of supplying some 500 lights. All the machinery is in duplicate, so as to act as a provision for special occasions, and to guard against breakdown, but it is worthy of notice that although the light has now been installed at the hall for about twelve months, and used in some parts day and night, on no occasion whatever has it failed, or been necessary to resort to the duplicate machinery. The illumination of the church is carried out by means of incandescent lamps, of which there are some twenty-five attached to specially designed hammered iron standards, and is carefully diffused by ruby glasses. The pulpit light is so arranged that the light is concentrated chiefly upon the book without being seen. The whole of the electrical work at the hall, stables, and church, and surrounding buildings, has been carried out and designed by Mr. Taylor-Smith, of 101, London-wall, London, E.C.

The Proposed Paris-Brussels Telephone Line.—We gather from the *Bulletin International de l'Electricite* that the negotiations which have been for some time in progress for the establishment of an international telephone line between Paris and Brussels have been brought to a satisfactory issue on all points save one. It appears that the French Government are prepared to construct a special metallic circuit line of silicum bronze wire from Paris to the frontier, and very naturally wish the Belgians to complete the line to Brussels on the same plan. The Belgian Government, however, entertains a decided preference for the Van Rysselberghe system, and as their contribution they offer to equip an existing telegraph wire with the Van Rysselberghe apparatus. The Belgians may be pardoned for entertaining a fondness for the methods introduced by their countryman; but there can, we think, be little doubt that they will be pushing the system beyond its proper sphere if they insist upon its employment in this particular case. We have always regarded the Van Rysselberghe system as an ingenious device whereby a wire not overburdened with telegraph work may in some cases advantageously be made to do double duty; but it is well known that the system is not applicable to telegraph lines worked at a high speed of transmission, nor is it conducive to the most satisfactory telephonic communication. According to our contemporary, the system has not met with any great success in France, the experience gained upon the Paris-Rheims line is spoken of in particular as by no means encouraging. Nevertheless we shall hope that the Belgian Government will consent to build a special metallic circuit line from Brussels to the French frontier, and in that case we have little fear for the success of the scheme.

Electricity in the West of England.—The *Western Morning News* writes as follows:—"It is cheering to see the spirit displayed by some of the more important towns in Cornwall in arranging for experiments with electric lighting, and Tavistock also shares the honour. But what about Plymouth and Devonport? Surely it is time that the metropolis of the West made some movement in the matter. The reason for their lethargy cannot be that the gas is so good and so plentiful, for there are few large towns in England the streets of which are worse lighted. As for the public buildings, it is painful to observe the 'dim, religious light' which is made in some of them to do duty for real illumination. There is scarcely a public building or church or chapel which is well lighted, and where even enough gas is burnt to make it easy to read, the heat throughout the greater portion of the year becomes so intolerable that the gas has to be turned down during a part of the evening, and that gives rise to a flickering which is most painful to the nerves and injurious to the eyes. Surely if in some central spot of Plymouth a powerful steam engine and an adequate dynamo were erected, it would be easy to supply a group of buildings, say the Guildhall, St. Andrew's Hall, George-street Chapel, Royal Hotel, the Theatre, and Athenæum, all within a compass of 500 yards; and the electric light would be a great attraction, as well as minister to the comfort and health of those who frequent the buildings. Some of the spirited tradesmen also would do well to give the matter their attention. It is true that shopping after dark has become unpopular, and desirably so; but for some months in the year it becomes dark in the shops and warehouses long before a reasonable hour for closing, and not only does the electric light supply a good light by which to judge of colours, which cannot be properly seen by the aid of gas, but the health of the *employés*, not to add the customers, is worthy of consideration. A co-operative experiment, to last a few months, would give the matter a fair trial, and even if the electric light be found to cost more than gas, it would be a luxury well worth some outlay."

Proposed Atlantic Cables.—The following letter appears in *The Times* of November 23rd:—"26, Old Broad-street, London, E.C., November 22nd. Sir: If you will kindly refer to the prospectus of the International Cable Company (Limited), which appeared in your columns to day, you will find the following paragraph, which, being printed in red letters, is evidently relied upon by the promoters, and is expected to act as an inducement to the public to subscribe their money to the new enterprise:—'The directors regard with interest the sudden change of policy by the Associated Companies, and the war of rates now ruling. Assuming this company obtains a fair share of the traffic, the lower capital, after allowing for working expenses, repairs, and renewal fund, would enable them even at 6d. to pay a satisfactory dividend.' For the information of possible investors, the following figures will be useful:—The total Atlantic cable traffic at the 6d. per word tariff yields £300,000 per annum. Presuming that the new company intend to lay two cables, their proportion would be 20 per cent., £60,000 per annum. If only one cable be laid, then their proportion would only be £30,000 per annum, which, irrespective altogether of the question of the capital cost of the new cables, would only be sufficient to pay working expenses and repairs, leaving nothing either for renewal fund or dividend. The conditions under which the Direct United States Cable Company succeeded in getting for a short time 37 per cent. of the whole traffic are entirely altered now. Then there were only four cables across the Atlantic, now there are ten. The tariff at that time was 3s. per word, and the traffic in consequence limited; now the tariff is 6d. per word and the volume of traffic enormous, so that the new company could not carry more than their proportion expeditiously. I have only dealt with that part of the scheme which, at an estimated cost of £830,000, is to connect Europe with Canada and the United States of America, because, as the bulk of the traffic at 6d. per word between the two countries is carried by the Anglo-American Telegraph Company, of which I am the managing director, I am in a position to state that the statistics I have given are absolutely correct. I think it desirable to say further that there are at present five

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companies, with ten cables, struggling to get a living out of the Atlantic cable traffic; four of them, to my certain knowledge, are earning no dividend, and the fifth must be having a pretty hard time of it.—I am, sir, your obedient servant, H. WEAVER, managing director."

THE BRUSH "COLOSSUS" AT WORK.—In the *Scientific American* Dr. Hale describes a visit which he paid to the Cowles Smelting Works on the occasion of the first run of the colossal Brush machine. He witnessed a pyrotechnic display which evidently excited his admiration. He says:—"The big dynamo was running at 380 horse-power, though capable of 500 horse-power when required. It was making 420 revolutions per minute, and, as the electricity was drawn off, it scintillated in a brilliant and continuous fusillade of sparks, varying in colour from white to emerald green, and occasionally flashing out in a burst of unusual splendour, yet perfectly controlled and free from danger to the spectators. The furnaces are charged with sixty pounds granulated copper, sixty pounds corundum, and thirty pounds coarse charcoal, besides the pulverised lime-coated charcoal used as packing. This mixture contains over 32 pounds of aluminum or about 54 per cent. of the corundum. Into the furnace thus charged pours the current from the colossus, fusing the almost infusible corundum like wax, causing its molecular structure to be broken up into its elements, and raising the temperature of the entire mass to a very high heat. Vent holes are left in the covering of the furnace, through which escape the liberated gases and some of the volatilised aluminum, the whole glowing with a bright flame which sometimes darts up to the height of many feet." The current is started at 2,000 amperes, and is allowed gradually to increase to about 2,400 amperes; at the same time the carbon electrodes are from time to time drawn asunder, till at last they stand wide apart, and the current flows freely through the entire furnace. The process of reduction takes about two hours. "The product appears in the form of a fused mass of metal embedded in the surrounding carbon. Most of this mass is an alloy of copper and aluminum, varying much in the proportion of the two. Mostly it exceeds the 10 per cent. of aluminum which gives the alloy of maximum strength, and is a brittle white metal, which is again fused with the addition of more copper to such an alloy as may be required. Sometimes there are found small fused rubies and sapphires. The suboxide of aluminum—never found in nature, and never before known to exist or to be capable of formation—is always present in larger or smaller quantities. I have also seen specimens of beautiful white fibrous alumina. With other charges, sub-oxides of silicon and titanium are found—very curious products indeed. The intense even heat partially fuses the carbon, and the electrodes are converted into graphite. The price of aluminum alloys has been reduced to a scale adopted by reckoning the value of the contained aluminum at 2·50dols. a pound, previous sales of that metal having been at the rate of 75 cents an ounce. The 10 per cent. alloy is said to be the strongest metal known, though alloys of a less per cent. have great utility, being tougher, but not so strong. Some specimens of the alloys made by the Colossus, which are simply cast, not wrought, have recently shown the phenomenal strength of 131,000 pounds per square inch. In the year 1885 the whole amount of aluminum produced is stated as 3,400oz., aluminum being then regarded as a precious metal. The capacity of the Colossus will enable it to reduce a larger amount than this, in the alloy with copper, within the period of twenty-four hours."

LISKEARD AND THE ELECTRIC LIGHT.—A meeting of ratepayers, convened by the mayor in response to a requisition, was held at the Guildhall, Liskeard, last evening, to consider the desirability of lighting the principal thoroughfares of the town with the electric light. After a few words from the mayor, Mr. J. Rogers, as one of the committee who arranged for the recent successful experimental lighting of the town by the electric light, explained that it was proposed to form a company, with a capital of £3,000, for the purpose of lighting the town with the electric light. One-third of the capital would be taken up by the firm of Laing, Wharton, and Down, of the second £1,000 five gentlemen had agreed to subscribe £100 each, and he believed another five would be easily found to take the same amount of shares, and the remaining £1,000 it was proposed to offer to the general public. The shareholders did not look for high dividends, but would be content with a modest three per cent. At present Liskeard paid £216 a year for the illumination of its public thoroughfares. Compared with other towns of equal size that was not an excessive amount. But for years past, from a mistaken sense of economy, the public lighting of Liskeard had been starved (applause). The promoters of the new company were prepared to light the town in a manner that would place it, in the illumination of its streets, on an equality with any town in the kingdom, but they must pay a little more for it than they were at present paying for gas. To place the public lighting of the town on a satisfactory footing, even with gas, they would require 36 additional lamps, which would involve an increased expenditure of £108 per annum, making in all £324 per year. For £350 a year the proposed new company would light all the principal thoroughfares of the town by electricity, and the remaining streets by either gas or oil. For an extra rate of 2½d. in the £, therefore, they would be able to have the principal thoroughfares lighted by electricity. With the town lighted by the electric light, he predicted that its trade would be improved, persons would be induced to come there to reside, and the ratable value of the town consequently increased.—Mr. Godfrey thought the municipality, and not a private company, ought to undertake the lighting of the town.—Mr. Wharton, replying upon the observations of previous speakers, said the electric light was being used ten or fifteen times more extensively in London that it was three or four years ago. Fewer streets, he admitted, were lighted by it, but that was because private companies undertook ridiculous contracts to light the streets by electricity at 20 per cent. below gas, and had in consequence come to grief. But the private use of the electric light had enormously increased. Nearly all the best hotels, theatres, and railway stations were taking it, and there was, in fact, hardly a large establishment that was not using it. Moreover, negotiations were in progress for a very big scheme of public lighting in London. He was prepared himself to find a third of the capital of any local company, and he would not do that if he thought he was going to lose his money.—Mr. S. W. Jenkins, as a member of the committee, testified to the accuracy of Mr. Rogers's figures, and added that the committee would undertake for £320 a year to place 18 arc lights in the principal thoroughfares, and light the rest of the town better than at present.—After some further discussion, it was proposed and seconded "That this meeting, having had placed before it the scheme proposed for the electric lighting of Liskeard, expresses its approval of the same, and recommends its adoption by the Town Council."—Mr. Ainge proposed an amendment declaring that the meeting did not feel justified in pledging itself to the increased rate which the electric lighting would involve. The mayor asked that none but ratepayers should vote. For the amendment there were 35 hands; for the resolution, 40.

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 31.)

Faraday's mode of experimenting consisted in suspending an elongated bar of the material to be tested between the poles of a powerful electromagnet. If the substance were magnetic the bar would assume an *axial* position—that is, it would set with its greatest length along the line joining the poles of the magnet. If the substance were diamagnetic the bar would assume an *equatorial* position—that is, it would set with its length perpendicular to the line joining the magnetic poles.

When a substance is not isotropic—*i.e.*, does not possess the same properties in all directions within its mass—it generally happens that the magnetic permeability is different in different directions. This is the case with most crystals which do not belong to the cubic system. In such cases the axial or equatorial setting of the bar is not a safe test to ascertain whether the substance is magnetic or diamagnetic, for a magnetic body may have a greater permeability in a direction at right angles to its greatest length and may thus set equatorially, while a diamagnetic body may have a greater magnetic permeability along its greatest length than at right angles to it, and may consequently set axially. This behaviour is known as magne-crystallic action. It is frequently exhibited by a bar of crystalline bismuth, which then assumes an axial position between the poles of the magnet

A diamagnetic substance behaves as though it had magnetic polarity induced in it, opposite in direction to that which would be induced in iron under the same circumstances. Its behaviour can, however, be imitated by suspending a bar of a magnetic substance within a liquid more magnetic than itself. In this case, the magnetic lines of force pass more readily through the liquid than through the bar, and in their endeavour to obtain a passage through the liquid for as large a part of their journey from pole to pole as possible, they compel the liquid to take the axial position, and the bar being pushed out of the way, is compelled to assume an equatorial position. Hence it has been inferred that diamagnetic phenomena are due to a differential action, and that all bodies, as well as vacuum, are acted upon in the same way by magnets, and have the same polarity induced in them, but that diamagnetic substances are those in which the action is less strong than in vacuum. This hypothesis accounts perfectly for the apparent polarity of diamagnetic substances. There is, however, one objection against the hypothesis. If a ray of plane-polarised light be made to pass through a transparent substance which is surrounded by a coil through which an electric current is flowing, the light passing parallel to the axis of the tube, the plane of polarisation will be turned round through an angle depending on the number of turns of wire in the coil, the strength of the current, and the nature of the transparent medium. If the medium be diamagnetic, the rotation is in the direction of the current. If the medium be magnetic, the rotation is in the opposite direction. In a vacuum, no rotation has been detected. This result indicates a difference in *kind* between magnetic and diamagnetic substances, and not simply one of *degree.*

If a bar magnet be suspended so that it can turn freely in all directions about its centre of gravity, it will set with its magnetic axis in the direction of the magnetic lines of force, supposing these lines to be sensibly parallel throughout the portion of space occupied by the magnet.

If such a magnet be exposed to the action of the earth alone in London, it will set with its magnetic axis inclined at an angle of between 67° and 68° to the horizon, the north end being the lower, while the vertical plane through the axis of the magnet will make an angle of about 18° with the geographical meridian, the north pole of the magnet pointing to the west of the geographical north.

Def. The vertical plane through the magnetic axis of a freely suspended magnet or compass needle at rest is called the magnetic meridian.

Def. The angle between the magnetic meridian and the geographical meridian is called the declination. By sailors it is more generally called the variation of the compass. It is reckoned east or west, according as the compass needle points east or west of true north.

Def. The angle which the magnetic axis of a magnet, capable of turning freely in all directions about its centre of gravity, makes with the horizon is called the *inclination* or *dip.*

The declination and dip are both found to vary continuously over the earth's surface. A line passing through all points for which the declination is the same is called an *isogonic* line; a line passing through all points for which the dip or inclination is the same is an *isoclinic* line. With a set of maps showing these lines for every degree, the mean declination and dip at any point of the earth's surface can be determined. At the magnetic equator, which does not coincide with the geographical equator, the dipping needle is horizontal. South of the magnetic equator the south pole of the needle is inclined downwards. At the magnetic poles the needle is vertical. The pole of the earth situated in the northern hemisphere is, of course, a south magnetic pole, since it attracts the north pole of a magnet. Sometimes the north-seeking and south-seeking poles of a magnet are called the austral and boreal poles respectively.

The declination and dip are not, however, constant at any place. Besides the irregular and great variations which occasionally take place, and which are known as magnetic storms, there are three principal changes in the declination, known respectively as the diurnal variation, the annual variation, and the secular variation.

The secular variation is a slow, steady change, which continues in the same direction for many years. Thus in 1580 the compass needle in London pointed 11° east of north. This declination diminished until the needle pointed due north in 1657, but continued moving westward till it attained its maximum westerly declination of 24° 27′ in 1816. Its declination is now about 18° 19′, and is decreasing at the rate of about 7′ per annum. The inclination attained a maximum of 74° 42′ in 1720, and since then has been steadily diminishing.

The daily variation consists of a very slight westward motion from 7 a.m. till 1 p.m., followed by an easterly motion which continues till about 10 p.m. In the summer this is followed by a second, though smaller excursion, westward, commencing at midnight, the needle returning before 7 a.m.

The annual variation consists in a change in the declination and dip, and in the intensity of the magnetic force, which change goes through all its phases in the course of a year. In the Northern Hemisphere the change of declination is westerly from May to September, and easterly from September to May. The total force attains a maximum in June. The reverse is the case in the Southern Hemisphere.

Def. The magnetic *intensity* (total intensity) at any point of a magnetic field is the force which would be exerted upon a north magnetic pole of unit strength placed at that point.

A magnetic field is completely known if we know the direction of the lines of force and the magnetic intensity at every point of the field.

Def. The *horizontal intensity* of the earth's magnetic force at any point is the horizontal component of the force exerted upon a north magnetic pole of unit strength placed at that point.

Def. The *vertical intensity* of the earth's magnetic force at any point is the vertical component of the force exerted upon a north magnetic pole of unit strength placed at that point.

The total intensity is, of course, the resultant of the horizontal and vertical intensities. Hence, of the four quantities, horizontal intensity, vertical intensity, total intensity, and dip, if any two be given the others can be found from the parallelogram (or triangle) of forces. Thus, if these quantities be denoted by H, V, I, and δ, respectively, we have,—

$$I = \sqrt{H^2 + V^2},\ V = \sqrt{I^2 - H^2},\ H = \sqrt{I^2 - V^2},$$

$$\sin \delta = \frac{V}{I},\quad \cos \delta = \frac{H}{I},\quad \tan \delta = \frac{V}{H}.$$

If a compass needle be brought near to the north pole of a large magnet its south pole will be attracted and its north pole repelled. Hence the needle will turn so as to present its south pole towards the north pole of the magnet. But its south pole being nearer to the pole of the magnet than its north pole the attraction will exceed the repulsion, and the needle will be bodily attracted. If the needle be placed in a

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uniform magnetic field the forces on its poles will be exactly equal and opposite, and, consequently, while the needle will be made to take up the direction of the lines of force it will have no tendency to move as a whole in one direction or another. Such a field of force is produced by the earth in any space of moderate dimensions. For example, there would be no sensible difference either in direction or intensity in the magnetic force of the earth within the space of an ordinary room, and the forces exerted by the earth upon the poles of any ordinary magnet will be equal and opposite, since both poles of the magnet may be considered as equally distant from the earth's magnetic poles. Hence the earth's horizontal force will have no tendency to move a compass needle horizontally as a whole, and its vertical force will have no tendency to move the needle vertically. Thus the apparent *weight* of a steel bar will be unaffected by magnetising it, and the action of the earth will be a *directive* action only. If a magnet be placed on a cork which is floating in water the magnet will take up the direction of the magnetic meridian, but there will be no tendency for the cork to move in any direction through the water.

But if a steel bar be accurately balanced about its centre of gravity and then magnetised, it will, as above stated, take up the line of the magnetic dip. If we wish the bar to remain horizontal while it is free to turn in the magnetic meridian we must balance it about an axis which in northern latitudes is nearer the north end of the bar than its centre of gravity is, and in southern latitudes is south of its centre of gravity. It is only at the magnetic equator that the bar will remain horizontal when free to turn about its centre of gravity. Compass needles are generally balanced about a point considerably above the centre of gravity, like the beam of a balance which has great stability. This prevents their dipping sensibly under the action of the vertical force.

(To be continued.)

IMPORTANT TESTS OF ENGINES.

We have always been amongst those who contended that trials of engines conducted by unbiassed parties were extremely valuable, not only to the makers of those engines but to the community at large. When the Royal Agricultural Society discontinued its annual trials England stood undoubtedly in the foremost position as engine makers in the world. Since then competitors have taken the designs from our best known firms and have followed in their footsteps. Emulation, more or less, ceased between these eminent firms, and it was generally feared that England had not made the progress she ought to have made. We are not at all sure that this conclusion is correct, and we think the important trials which took place just before the close of the Colindries will go far to restore the confidence of Englishmen, and to assure them that they are not yet reached by any of their Continental rivals, so far as thoroughly good workmanship and economy are concerned. We heartily congratulate Messrs. Paxman and Co. for having come forward voluntarily and allowed the public to obtain perfectly trustworthy and satisfactory tests of the engines which have been running and doing good work for the past three years at the South Kensington Exhibitions. Our space is far too limited to enter into any discussion of the figures in the present article, so that we must content ourselves with giving as full information of the trials as possible, leaving the figures and diagrams to speak for themselves. It will be seen that the trials were carried out by Mr. W. E. Rich, M.I.C.E., and Prof. Kennedy, M.I.C.E, with an able staff of assistants. The reputation of these gentlemen is second to none as regards ability to take tests, and the results obtained by these absolutely independent authorities must be taken to be as nearly accurate as modern science can make them. Two separate reports have been made of these tests, one by Mr. Rich, and the second by Mr. Rich conjointly with Prof. Kennedy. We give below a few paragraphs from the former of these reports, and the whole of the conjoint report, the latter dealing more especially with the tests, the former containing more general references. Among other things, Mr. Rich says:—

"The results of the trial detailed in the following report must tend largely, I think, to confirm the good opinions of the public regarding engines of this type.

"The engines, when you first introduced me to them officially on the 20th of October last, were driving two dynamos for electric lighting purposes at the Colonial and Indian Exhibition, and I learned from you that they had been working steadily day after day through three successive Exhibition seasons, on similar duties, without any material repairs or overhaul, that no special overhaul of them had been made for preparing them for the present trial, which took place at the end of an Exhibition season, and that consequently the present test might be taken as that of such engines in current working condition. . . . I understand your instructions to me to be that you would place the engines, with the ordinary fireman and engine driver, unreservedly under my control, and that you desired me to carry out the most perfect test of their economical performances (especially in steam and coal consumption) which was practicable during the seven hours' run of their ordinary daily duty when driving the two dynamos. . . . We provided ourselves for the purposes of the trial with a powerful staff of assistants, so that all important records were at least doubly checked, and we divided the work of supervision in the following manner:—For the operations of starting and stopping under the most uniform condition of coal on fire, water in boiler, steam pressure, &c., to which the greatest possible importance in such trials must be attached, we both attended in the stoke hold, and checked the facts and figures carefully with one another.

"In the interim, during the currency of the trial, I devoted attention to the general control of it, the measurement and official logs of coal, feed water, steam and water gauges counter, temperatures, &c., while Prof. Kennedy directed the staff, taking and reducing the indicator diagrams; and at a table placed near the engines he plotted the records and results, with curves of increments and averages, as fast as we obtained them, so that any irregularity would have been noticed immediately, and I cannot speak too highly of the value of keeping such records up to date in such a trial.

"The day was damp, indeed it was raining during the afternoon, and the steam pressure was less than that at which you desired to work. I am not prepared to give an opinion as to the amount of loss due to damp weather, but it is generally considered by practical men to be prejudicial to such a trial, and no doubt 115lb. steam would have given somewhat higher results than 107lb. In case the way in which the intermediate records during the currency of the trial have been tabulated and recorded graphically should be criticised as being unnecessarily elaborate, and leading to useless work in reductions, &c., I would have it understood that I attach great value to these frequent statistics, as they evidence distinctly whether the trial has proceeded fairly and uniformly, they enable sub-trials within the main trial to be criticised, and sometimes when an unexpected hitch occurs, stopping a test altogether, a short trial of sufficient length to give valuable information may be taken out of the incompleted records. The most difficult matter in such a trial is to get the fire uniform at the beginning and the end. The curves of increment—see Appendix E—are the best check on this. The longer a trial is, the less the error from such lack of uniformity.

"The variation of the coal consumption even in the long intervals shown near the top of the curve sheet, Appendix E, shows how little value can be attached to the reputed coal consumption, when the trial is of very short duration.

"I now beg to hand you the following joint report by Prof. Kennedy and myself on the trial and its results.—I remain yours very truly, (Signed) "WILLIAM E. RICH."

Westminster, S.W., Nov. 15, 1886

Jas. Paxman, Esq, Colchester.

DEAR SIR: In accordance with your request, we, on 27th October last, carried out a trial of the economic performances of your 40 horse-power semi-fixed compound engines, which were

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then driving two dynamos in the south-west corner of the electric light shed at the Colonial and Indian Exhibition.

The cylinders and working gear of these engines are fitted to a bed-plate placed beneath the barrel of the boiler, the cylinders themselves being side by side under the smoke-box.

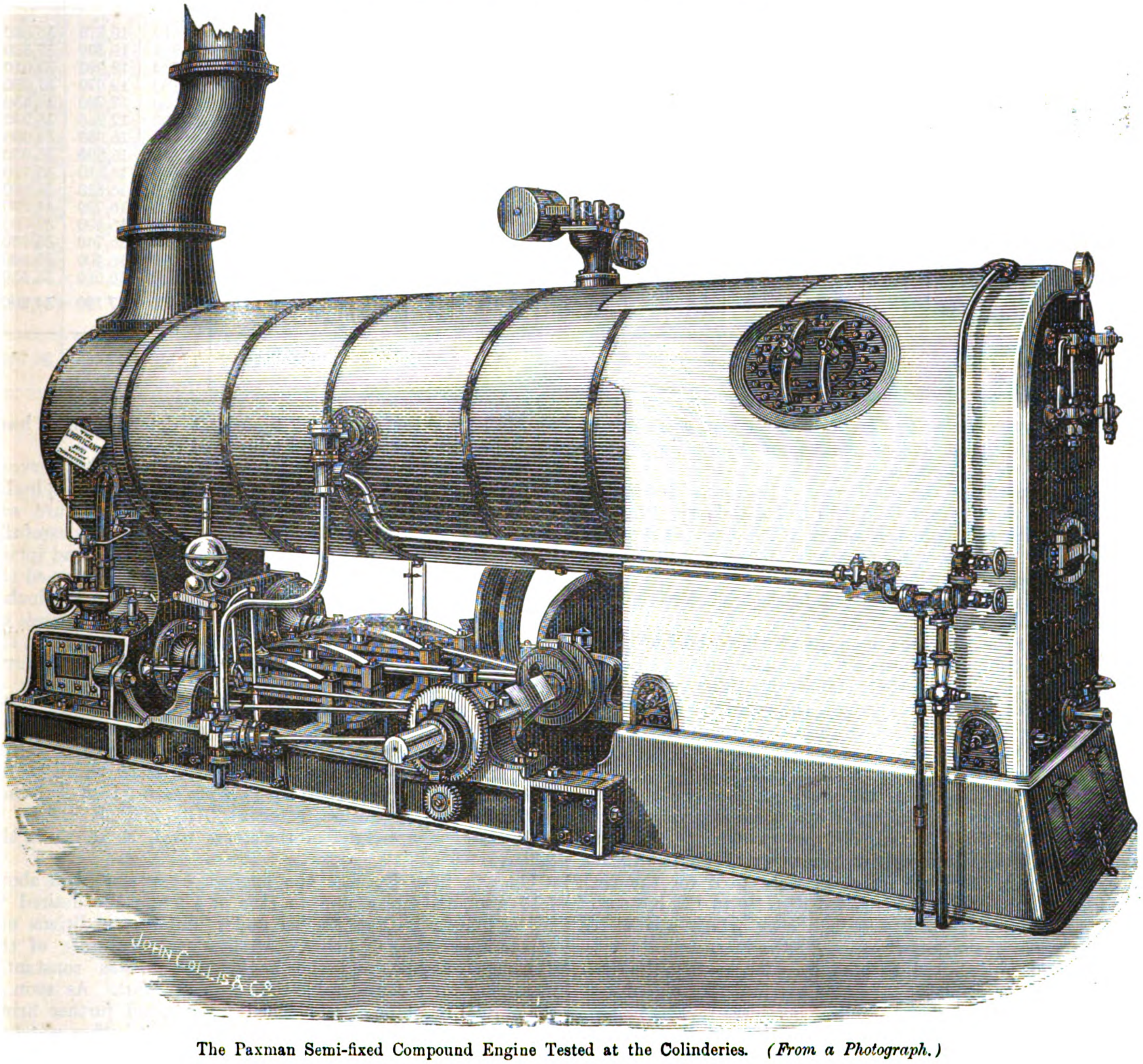
The cylinders are fitted with steam jackets, but at the time of the trial no steam was admitted to the jacket spaces, which were supposed to be full of dry, warm, stagnant air, which would act as a non-conductor. The external cylindrical surfaces are lagged, and the boiler shell is coated with non-conducting composition.

The admission of steam to the high pressure cylinder is regulated by a gridiron valve, the stroke of which is controlled

Barrel of boiler, 4ft. 5in. diameter, 12ft. 8in. long, over smoke box.

Heating surface in firebox	88 sq. ft
„ tube surface 100 tubes, 2¼dia., outside, 10ft. 7in. long between tube plates	623 „ „
Total.....................	711 sq. ft.
Firegrate (ordinary) 5ft. long × 3ft.10in. wide...	= 19·2 sq. ft.
Firegrate reduced size for trial, 4ft. 7in. × 3ft. 4¼in.	= 15·3 „ „
Firegrate air spaces between bars, total	= 4·56 „ „

Chimney, 17in. diameter.



The Paxman Semi-fixed Compound Engine Tested at the Colinderies. *(From a Photograph.)*

by the governor which actuates a block in a suspended link. The exhaust valve for the high-pressure cylinder and the main slide valve of the low-pressure cylinder are placed in an intermediate receiver between them.

The following are the leading particulars of the engines furnished to us by your firm :—

High-pressure cylinder, 12¼in. diameter × 24in. stroke.
Low-pressure „ 20in. „ × 24in. „
Steam stop valve, 3in. diameter.
Exhaust nozzle, 4⅜in. diameter.
Steel locomotive boiler, 18ft. 4in. long over smoke box.

The boiler is proportioned for a working pressure of 120lb. to 140lb. per square inch, but at the time of the trial the safety valves began to blow at 115lbs. per square inch.

To be precise, we had the cylinder covers removed after the trial, and personally verified the strokes and diameters. The strokes are as stated above, but the high-pressure cylinder diameter is now 12·28in., and the low-pressure 20·03in. diameter, the barrels having worn slightly from continuous use, but being in excellent order. The co-efficients used in calculating the power from the diagrams are based on these figures, after allowing for the piston rods, which are 2¼in. diameter. Previously to the trial we examined the pipe con-

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Appendix A.—Table I.—Abstract Log of Trial.

Time at which stoker began to serve each 100lb. of coal on fire.	Total coal served on fire previously.	Other records at same time.					Evaporation out of boiler by lowering water in it since start.		Total weight of steam used in engines since start.	Indicator Experiments.						
		Counter.	Steam pressure in lbs. on square inch.	Temperature of feed water Fahr.	Total weight of feed water served into boiler in lbs.	Height of water in gauge glass on boiler.	In inches on gauge.	In lbs. weight of water at 310lb. per inch deep.		Register number of set of diagrams representing mean work per rev. since last reading.	Approximate time at which these diagrams were taken.	Mean pressures indicated. In high-pressure cylinder.	Mean pressures indicated. In low pressure cylinder.	Foot-lbs. of work indicated per rev. as per diagram. High pressure cylinder =460ps.	Foot-lbs. of work indicated per rev. as per diagram. Low pressure cylinder =1,258ps.	Total.
h. m.						in.					h. m.					
10:12	0	0	100	55°	0	1·4	...	...	...	...	...	...	...	...	...	...
10:25	100	1,340	110	...		1·7	– ·3	– 93	...	1	10:20	37·8	15·38	17,610	19,270	36,880
10:51	200	4,030	111	56	1,720	1·5	– ·1	– 31	1,689	2	10:37	39·1	15·40	18,220	19,300	37,520
11:12	300	6 210	109	...	2,600	1·0	+ ·4	124	2,724	3	11:1	38·7	15·15	18,030	18,980	37,010
11:35	400	8,690	110	55	3,670	·9	·5	155	3,825	4	11:25	39·0	15·22	18,180	19,070	37,250
11:57	500	10,880	109	...	4,560	·8	·6	186	4,746	5	11:48	36·8	13·79	17,150	17,280	34,430
12:20	600	13,280	105	...	5,600	·7	·7	217	5,817	6	12:8	38·6	13·77	17,990	17,250	35,240
12:42	700	15,560	105	55	6,570	·8	·6	186	6,756	7	12:30	36·7	13·53	17,100	16,950	34,050
1:3	800	17,760	107	56	7,410	·8	·6	186	7,596	8	12:52	37·2	13·24	17,340	16,590	33,930
1:23	900	19,840	109	...	8,360	·8	·6	186	8,546	9	1:13	35·1	13·42	16,360	16,810	33,170
1:46	1,000	22,230	107	55	9,220	·5	·9	279	9,499	10	1:33	36·9	13·42	17,200	16,810	34,010
2:2	1,100	23,910	108	...	10,000	·6	·8	248	10,248	11	1:56	37·7	13·34	17,570	16,720	34,290
2:24	1,200	26,190	110	56	10,940	·7	·7	217	11,157	12	2:12	34·7	13·24	16,170	16,590	32,760
2:46	1,300	28,480	109	...	12,000	·9	·5	155	12,155	13	2:34	37·1	13·36	17,290	16,740	34,030
3:8	1,400	30,780	105	55	13,090	1·5	– ·1	– 31	13,059	14	2:55	37·1	13·09	17,290	16,400	33,690
3:26	1,500	32,650	106		13,500	·4	1·0	310	13,810	15	3:18	36·0	13·21	16,780	16,550	33,330
3:54	1,600	35,550	100		15,040	1·3	·1	31	15,071	{16 {17	3:36} 3:50}	36·7	13·72	17,100	17,190	34,290
Averages—			107	Mean of 19 records 55·5 deg.								37·2	13·89	17,336	17,406	34,742

nections about the boiler and engines, to see that there was no connection with other boilers, and at our request the injector and its pipes were disconnected.

The coal used on the trial was "Radford's Navigation Welsh Steam Coal," from Radford's Hafod Colliery, Rhondda Valley, and it was weighed in lots of 100lb. each, as the trial proceeded, on a new weighing machine, which was verified by us, both before and during the trial.

Each lot of 100lb. was charged on to the fire before the next lot was served out on to the stoking floor.

Throughout the trial, the moment at which the first shovel full of each 100lb. of coal was served on the fire was signalled by a sharp whistle to the whole staff by Mr. Rich, and records of the condition of all the gauges, the counter, and the feed water consumption were then taken simultaneously and recorded in the official log.

The feed was measured in a rectangular tank in which we had fitted a float gauge, so that at any moment we could see how many pounds weight of water had been previously served into the boiler. The float scale was graduated by us by pouring into the tank successive quantities of water of 60lbs. each, weighed in the same scales as were used for the coal. The feed suction pipe was connected directly to the bottom of this tank, and was furnished with a cock which was closed precisely when the float fell to the 800lbs. mark.

We found pipes fitted to each cylinder, so that the cards from both ends could be taken on one indicator placed midway between them, but our joint experiences told us that we could not hope to get reliable results taken in that manner, and we consequently had the pipes removed, and placed two "Darke's" indicators close to the respective ends of the high-pressure cylinder, and two "Richards" indicators on the ends of the low-pressure cylinder. The former had $\frac{1}{48}$ springs in them, and the latter $\frac{1}{20}$ springs. The instruments and springs were all supplied by us, and had all been tested comparatively recently.

The four diagrams forming a set were taken simultaneously, as nearly as possible in the middle of the interval between the times at which the successive lots of coal began to be charged on the fire, as shown in the log. The indicator cards were measured in the first place during the trial by ordinates, but subsequently, to be more precise, they were remeasured with a carefully tested planimeter, which gave results 1·8 per cent. less, and these last determinations have been adopted in the enclosed tables and records.

At an early period in the trial we were somewhat nervous that the pressures at the back of the high-pressure cylinder were imperfectly indicated, as the initial steam pressure was much lower than at the front end, but the matter was carefully investigated by Prof. Kennedy, and the indicator and spring were changed twice over, with results which confirmed the accuracy of the previous diagrams. Scales graduated in inches and decimals were placed against the water gauge glasses on the boiler front, so that the variations of water level in the boiler could be recorded precisely. The alterations of level in the gauges were very gradual throughout, without any of the rapid alterations sometimes noticed on such trials. The steam supplied to the engines was apparently remarkably dry all day. The area of the boiler at mean water level during the trial was measured, and the weight of water in it, at the mean steam temperature, corresponding to each 1-10th of an inch on the scale, was thus estimated at 31lb., and allowed for in determining the weight of the steam used, as shown in the tables.

On the 27th October the engines were started at about 7:15 a.m., and were due to stop at 4 p.m. We desired to get as long a trial as possible under uniform conditions out of the intervening 6¾ hours. At first the resistance of the dynamos was low, and the engine power was constantly increasing for a considerable time after the start. As soon as the normal resistance was reached we stopped further firing and feed, swept the stoking floor clear, and together watched the pressure gauge till from the lowering of the fire (which we also inspected from time to time) it fell to 100lb. per square inch. At that moment, viz., 10:12 a.m., the first signal was given, the counter, which stood at 0, was thrown into gear, the gauges were all noted, and the first shovel full of the first 100lb. lot of coal was put on the fire. The feed tank was full, and shortly afterwards we began to charge measured feed water into the boiler, and at 10:20 the first set of diagrams was taken. Records at frequent intervals, as described above and shown in abstract log of trial, followed for 5 hours 42 minutes. At 12:30 the fireman began to use some of the few ashes which had accumulated in the ashpit since the start. At 3:26 we told him that the 100lb. lot of coal then commenced would be the last served out to him,

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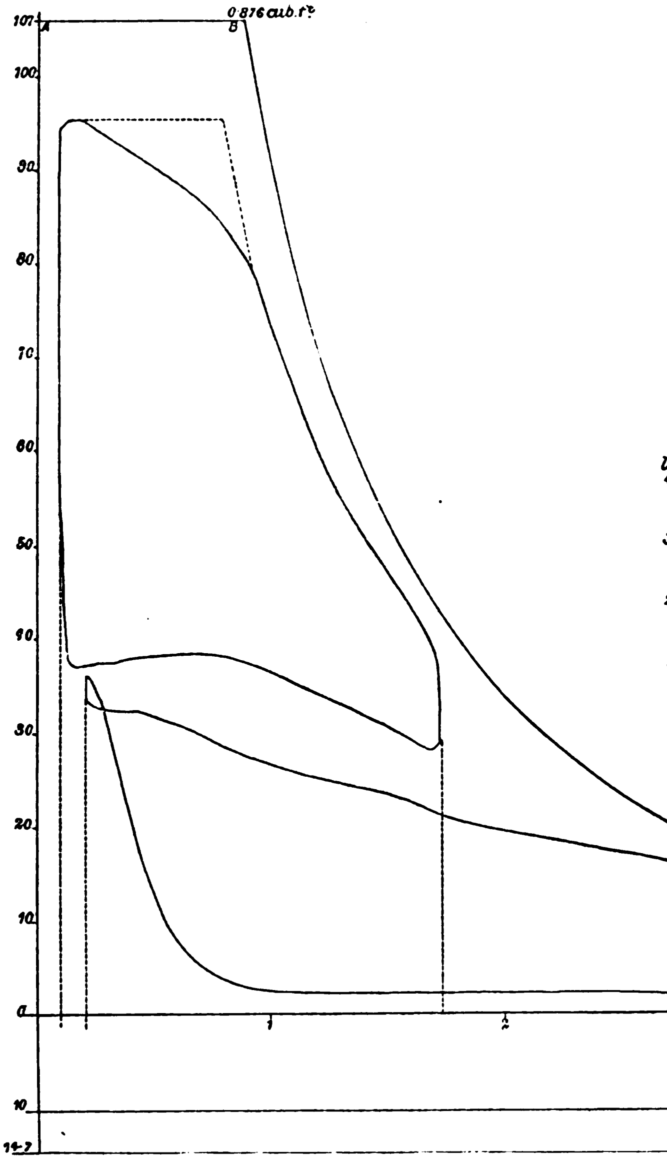
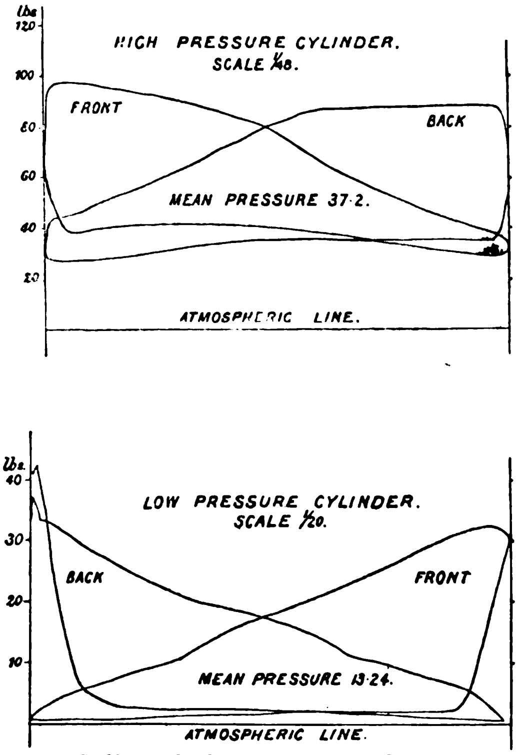
APPENDIX B.—TABLE II.—RESULTS OF TRIAL.

Time.	Increments since last Reading.					Totals since Start.					Average since last Reading.								
	Number of Minutes.	Counter.	Coal in lbs.	Weight of Steam used in lbs.	Ft. lbs. of Work indicated in millions of ft. lbs.	Number of Minutes.	Number of Revolutions.	Coal served on fire previously to this reading.	Weight of Steam used in Engines.	Ft. lbs. of Work indicated in millions and decimals.	Revolutions of Engines per minute.	Indicated Horse-power. For short intervals.	Indicated Horse-power. For long intervals.	Weight of steam used in engines per indicated horse-power per hour.	Coal burnt per indicated horse-power per hour.	Units of Evaporation or lbs. of water at 212deg. Evaporation at 212deg. per lb. of coal.	Coal burnt per sq. ft. of grate surface per hour—grate area 15·3 sq. ft.	Grate surface per indicated horse-power.	Heating surface per indicated horse-power—heating surface 711 sq. ft.
a.m.																			
10:12		0	com	mence	ment	of	trial.												
10:25	13	1,340	100	...	49·4	13	1,340	100	...	49·4	103·1	115·2							
10:51	26	2,690	100	1,689	100·9	39	4,030	200	1,689	150·3	103·5	117·6	116·5	23·42	2·45	11·39	18·7	·131	6·1
11:12	21	2,180	100	1,035	80·7	60	6,210	300	2,724	231·0	103·8	116·4							
11:36	24	2,480	100	1,101	92·4	84	8 699	400	3,825	323·4	103·3	116·7							
11:57	21	2,190	100	921	75·4	105	10,880	500	4,745	398·8	104·3	108·8							
12:20	23	2,4[illegible]0	100	1,071	84·6	128	13,280	600	5,817	485·4	1[illegible]4·3	111·5							
p.m.													108·8	23·92	2·54	11·32	18·0	·141	6·5
12:42	22	2,280	100	939	77·6	150	15,560	700	6,756	561·0	103·6	106·9							
1:3	21	2,200	100	840	74·6	171	17,760	800	7,596	635·6	104·8	107·6							
1:23	20	2,080	100	950	69·0	191	19,840	900	8,546	704·6	104·0	104·6							
1:46	23	2,390	100	953	81·3	214	22,230	1,000	9,499	785·9	103·9	107·1	105·7	24·9[illegible]	2·80	10·69	19·4	·145	6·7
2:2	16	1,680	100	749	57·6	230	23,910	1,100	10,248	843·5	105·0	109·1							
2:24	22	2,280	100	9[illegible]9	74·7	252	26,190	1,200	11,157	918·2	103·6	102·9							
2:46	22	2,290	100	998	77·9	274	28,480	1,300	12,155	996·1	104·1	107·3							
3:8	22	2,300	100	904	77·5	295	30,780	1,400	13,059	1073·6	104·5	106·7	106·8	24·44	2·50	11·91	17·4	·143	6·7
3:26	18	1,870	100	751	62·3	314	32,650	1,500	13,810	1135·9	103·9	104·9							
3:54	28	2,900	100	1,261	99·4	342	35,550	1,600	15,071	1235·3	103·6	107·6							
5 hrs. 42′	342			15,071	1235·3						103·9	109·5		24·15	2·56	11·33	18·3	·740	6·5





Indicator Cards, Set VIII. 12:52 p.m.

Expanded Indicator Cards. The ordinates of each card in this figure are the means of a pair (front and back) of actual indicator cards. The length A B, represents the volume of steam, at boiler pressure, corresponding to the measured feed water per (single) stroke. The line, B C, is the theoretical (adiabatic) expansion curve for this quantity of steam in a single unjacketted cylinder. Scale of volumes=0·4 of cubic ft. to ½in.

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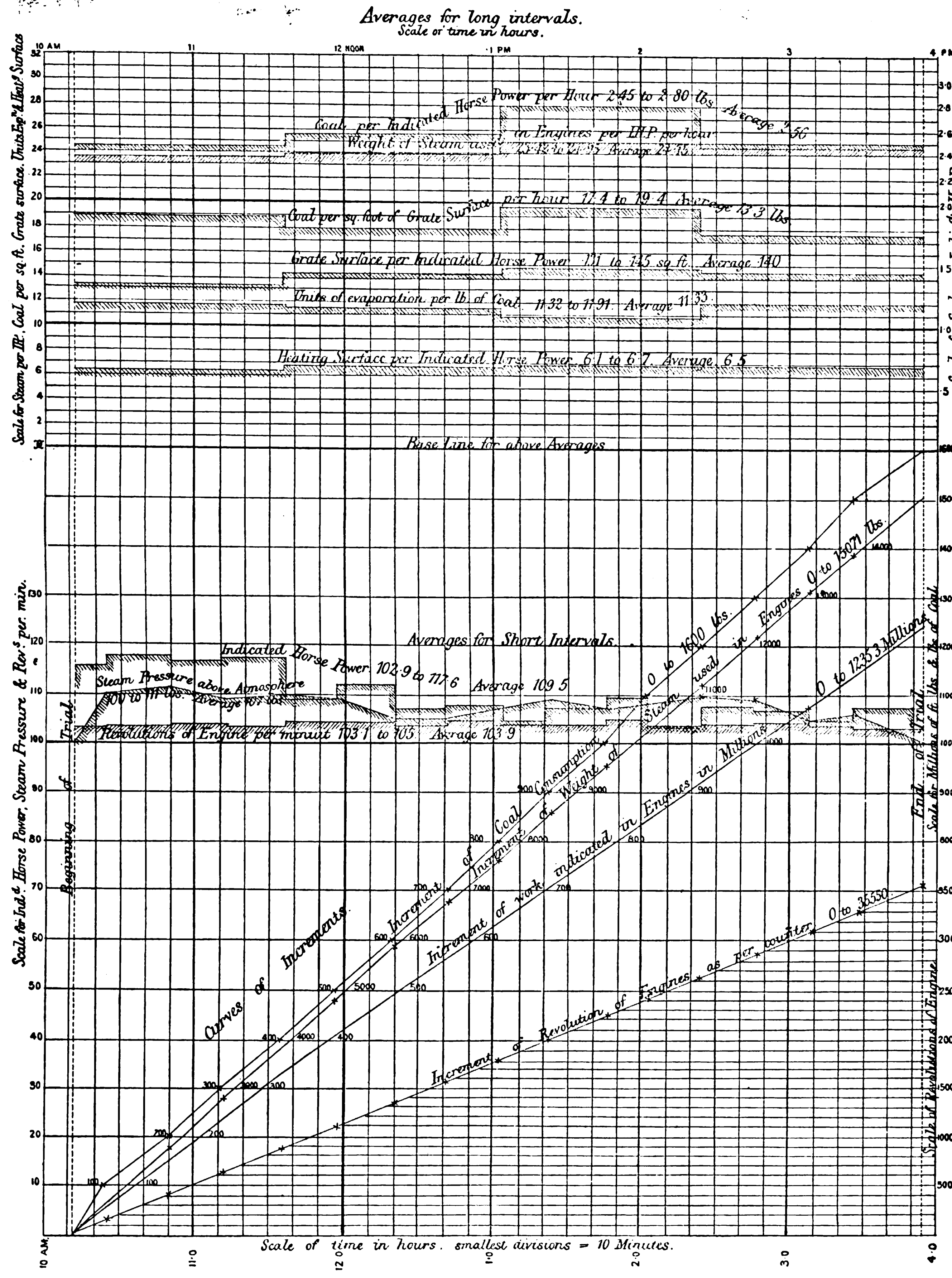
APPENDIX E

TRIAL OF DAVEY PAXMAN & C^os SEMI-FIXED COMPOUND ENGINE.



and that he must make the most of it and the ashes which remained. At the same time we arranged so to adjust the feed service as to get back the water in the boiler as nearly as possible to the level at which we started. When at last the fire became unequal to make the steam demanded by the engines, the steam pressure began to fall, and we together watched it narrowly till, on its reaching 100lbs. exactly, the final signal was given, the counter was pulled out of gear,

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the gauges and water tank consumption were all taken, and the trial was at an end, viz., at 3:54 p.m., having lasted 5 hours 42 minutes.

During the whole trial the engine power, speed, steam pressure, &c., were remarkably uniform, the steam was dry, and there was no hitch or inconvenience of any kind from beginning to end. No handle about the engine was touched, excepting that on the feed suction cock and the water gauge cocks; the steam starting valve was wide open, the speed being controlled solely by the governor. The fireman regulated his fire and the feed water to meet the current requirements of steam.

Beyond the observations recorded our assistants took many intermediate records, which on being plotted have been found to further confirm the accuracy of those given in the official log. The logs and results are given *in extenso*:—

In Appendices

A. Table 1, Abstract Log of Trial.
B. Table 2, Result of Trial.
C. Specimens of indicator diagrams.
D. Expanded diagrams with a diabatic curve.
E. Diagrams showing curves of increments and averages and the general results of the trial graphically.

The following is a summary of the results:—Duration of trial, 5 hours 42 minutes = 342 minutes, or 5·7 hours.

Totals.

Revolutions, 35,550.
Coal served on fire = 1,600lb.
Weight of steam used in engines = 15,071lb.
Foot-lb. of work indicated = 1,235·3 millions.
Number of sets of indicator diagrams, 17.

Averages.

Steam pressure in boiler = 107lb. per sq. inch.
Revolutions per minute, 103·9.

Indicated pressure in high-pressure cylinder ..	37·2
Indicated pressure in low-pressure cylinder...	13·89
Indicated horse-power, high-pressure	54·6
Indicated horse-power, low-pressure	54·9
Total	109·5
Weight of steam used in engines per indicated h-p. per hour	24·15lb.
Coal burnt per 1 h.-p. per hour	2·56lb.
Water evaporated per lb. of coal	9·42lb.
Mean temperature of feed	55·5°
Units of evaporation or equivalent weight of water at 212° evaporated at 212° per lb. of coal	11·33
Calorific value of coal used as per mean of 6 experiments with calorimeter at University College	13·9
Efficiency of fireman, furnace, and boiler $\frac{11·33}{13·9}$	815.
Coal burnt per square foot of reduced grate per hour	18·3lb.
Grate surface per indicated h.-p.	·14 sq. ft.
Heating surface „ „	6·5 sq. ft.

The above results speak for themselves. We consider them eminently satisfactory for high-pressure engines in regular work without any special preparation for trial.—We remain, Dear Sir, Yours faithfully,

(Signed) William E. Rich, M.I.C.E.
Alex. B. W. Kennedy, M.I.C.E.

The Electric Light in Austria.—We learn from *Industries* that the town of Graz, the capital of Styria, is to have its streets lit by electricity, power being obtained from the River Mur.

South of England Telephone Company.—The directors of this company, at their meeting yesterday, declared a dividend of 6 per cent. per annum on the preference shares of the company, for the half year ending 31st October.

NEW ZEALAND CABLE TARIFFS.

The following correspondence speaks for itself. It will be seen that the suggestion of Sir Dillon Bell has been accepted. It speaks volumes for the desire of the Eastern Extension Company to meet the wishes of the Australian and New Zealand authorities, and the wants of the telegraphing public, in that authorisation has been given to refund the extra charges due to the raising of the tariff:—

Sir Julius Vogel, Wellington, to Chairman Eastern Extension Company.

20th November, 1886.

15th November. If Press guarantee can be satisfactorily arranged, I will agree to *status quo ante.* Have instructed Dr. Lemon to endeavour to arrange with your Superintendent on basis that Australian Press arrange with you direct or through Sydney Government. Reuter makes his own arrangement, and we act as sponsors for Press Association. We understand Press message same meaning as hitherto, code words mixed with plain ones.

Chairman Eastern Extension Company to Sir Julius Vogel, Wellington.

23rd November, 1886.

Your telegram fifteenth only received yesterday, owing to derangement of service by cyclone in India. The proposal to revert to *status quo ante* for six months was Sir Dillon Bell's suggestion, and with view to meeting interests and convenience of telegraphing public Company accepted it. The reduced rate for Press with guarantee was your suggestion, and we accepted it on condition that your Government ensured the guarantee. As, however, the removal of deadlock is so essential to telegraphing public, Company will not on account of any difficulty with Australian Press delay reverting to *status quo ante* as proposed by Sir Dillon Bell, and will accept your Government's guarantee for Press Association at once, and you may then be able to arrange the guarantee in regard to Australian Press and Reuter during next six months. It must be distinctly understood that Press telegrams are to be wholly in plain language in accordance with the rules laid down when two shillings and eightpenny rate for International telegrams and other special rates were arranged. Code language has never been permitted over any lines in Press telegrams carried at reduced rates.

Chairman Eastern Extension Company to Postmasters-General Victoria, New South Wales, and South Australia.

23rd November, 1886.

I forward you copy of telegram which I have to-day addressed to Sir Julius Vogel, and which practically removes the deadlock for present. I hope before the six months expire that the New Zealand connection with Australia will be put on a satisfactory footing for the future. I also hope that the Australian Governments will see the desirability of considering the Company's guarantee proposal, as it would give the colonies complete control over telegraph system, and enable them to make the rates what they please.

Agent, Melbourne, to Eastern Extension Company.

23rd November, 1886.

Postmasters New South Wales and South Australia ask Chairman to authorise reverting to New Zealand former tariff for ordinary messages, pending settlement of Press guarantee.

Chairman Eastern Extension Company to Postmasters-General Victoria, New South Wales, New Zealand, South Australia, Queensland.

24th November, 1886.

In continuation of my telegrams of yesterday, and to make the *status quo ante* complete, I authorise you to refund to the senders of messages the additional charge of 4s. collected for the New Zealand Cable since the 1st November.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Cheques and P.O. Orders to be made payable to C. H. W. BIGGS.

Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XVII.

Volume XVII. of "The Electrician," price 10s. 6d., is now ready.

Also cases for binding, price 2s.

ANSWER TO CORRESPONDENT.

ELECTRICIAN (Preston).—*Any book on telegraphy, such as Preece and Sivewright's, Culley's, or Kempe's "Handbook of Electrical Testing," will give you the information you require.*

CONTENTS.

Notes	47
Elementary Electricity and Magnetism—II. (Continued.)	51
Important Tests of Engines. Illustrated	52
New Zealand Cable Tariffs	57
THE JUBILEE OF THE ELECTRIC TELEGRAPH	58
PROPOSED ATLANTIC CABLES	59
Correspondence	59 and 60
Incandescent Lamp Manufacture. By J. Swinburne	60
Prof. Bouty on Electrolytic Conductivity. (Concluded.)	61
Sur la Conductibilite Electrique des Dissolutions Salines très Etendues. By M. E. Bouty. Illustrated	62
Society of Telegraph-Engineers and Electricians	63
Dynamo-Electric Machinery. By J. Hopkinson, M.A., and E. Hopkinson, M.A. (Continued.) Illustrated	63
Legal Intelligence	65
The Blackpool Electric Tramway Company	68
Companies' Share List	68

THE JUBILEE OF THE ELECTRIC TELEGRAPH.

Preparations for celebrating the QUEEN'S JUBILEE have called to mind the fact that the year 1887 is the fiftieth anniversary of the ELECTRIC TELEGRAPH. In 1837 was erected the first telegraph line, which became the parent of all the telegraph lines that are now in existence. The line was a very short one, extending only from London to Blackwall, and it was regarded, at all events by lookers on, as a mere experiment. In an encyclopædia published about that date the cautious remark is hazarded that "several interesting trials have been made to test the practicability of conveying intelligence with the speed of lightning by means of galvanism." A promise is made that "these will be explained in the supplement of this work;" but as the promise was not redeemed we may infer that the learned compilers of the work in question, who devoted a whole column to the subject of telegraphic signalling by mechanical appliances, had not even at the termination of their labours formed any sanguine estimation of the scheme for signalling "by means of galvanism." And it is no doubt a fact that for some few years subsequent to the year we have named, the difficulty of finding capitalists to take up the idea prevented its getting much beyond the experimental stage. Nevertheless, the Blackwall telegraph line was a complete success; it demonstrated for the first time and beyond all question the practicability of electrical signalling; and in that very year—the year of the QUEEN'S Accession to the throne—we must fix the first birthday of the ELECTRIC TELEGRAPH.

Whether the Jubilee of this noteworthy event would have been allowed to pass without any public notice is more than we can say; but as the QUEEN'S JUBILEE has reminded us of it, we are strongly of opinion that the occasion ought to be marked in some appropriate and adequate fashion. Later on we may indicate more specifically in what way this should be done; but for the present we need only remark that any befitting scheme that may be set on foot will almost certainly have the cordial support of the public, not only in England, but in her Colonies, and perhaps also in America and on the Continent. The immense importance of the electric telegraph is nowadays universally recognised. No invention of modern times can pretend to outdo it in point of utility; and the only rival to be compared with it would have been paralysed in its progress but for the aid which the electric telegraph has rendered it. As instruments of civilisation, of commerce, and of universal good fellowship, the railway and the telegraph have worked hand in hand; and the world now, perhaps, could as ill spare the one as the other. Locomotion has immensely developed in the course of these fifty years; but the telegraph, if possible, even more. In the notice from which we have already quoted, we are told that at that time "Twenty-seven telegraphs convey information from Paris to Calais in three minutes." This was sharp work for semaphore signalling, even if the information was only two or three movements of the indicating arms, which had to be translated by means of the "telegraphic dictionaries" of those days. But to-day one electric telegraph does the same amount of work over thrice the distance in less than as many seconds. It is as popular as it is useful; and when the time approaches for celebrating its half-century there will be no lack of sympathising friends outside the profession most closely identified with the construction and maintenance of electric telegraph lines.

Confidently leaving this particular aspect of the subject to future consideration, we would now ask leave to call more particular attention to a matter nearly related to it which will not bear to be postponed. The time for electing the President of the SOCIETY OF TELEGRAPH-ENGINEERS and ELECTRICIANS is fast approaching, and whatever selection is then made will have to hold good during the session of 1887. Now, it is obvious that this Society must take a prominent—and ought, indeed, to take the leading—part in any organised effort to commemorate the TELEGRAPH JUBILEE in a becoming manner. The choice of a President on this occasion is, therefore, a matter of considerable importance, and one that ought not to be settled hastily, or necessarily on the ordinary lines. Indeed, to follow ordinary precedent on an extraordinary occasion like the present would betray a slavish adherence to custom, or a want of moral courage, which we could not help regarding as reprehensible. A special selection should unquestionably be made in the special circumstances anticipated for next year; and the Society should cast about it carefully to obtain the services of a President who will not only represent it with dignity, but conduct its affairs with energy and discretion. If the routine of rotation has brought

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round an officer of the Society who will meet these requirements, all the better; but if there be the least doubt about it, we strongly recommend the Council to disregard routine for once in a way, and fearlessly decline to nominate the wrong man.

To the question: What is the right sort of man? we have already replied as plainly as possible: *Who* he may be is not for us to say. There is a choice among several different sets of representatives—the representatives of electrical science, the representatives of historic telegraphy, the representatives of the Society. As regards their relative claims to the presidency during the Jubilee Year there is, perhaps, not very much to choose between them. A choice might be made from any one of them, providing the person selected be a suitable one. Perhaps the least suitable class to select from would be the purely scientific. It does not exclusively represent electric telegraphy, and in a general way is too much preoccupied to furnish the practical business aptitude which is wanted for the purpose in view. Among the second class there is a better field of choice; but on that very account it may be feared that rivalries and jealousies might create difficulties not easily surmounted. The original inventors of the telegraph are no longer among the living. Who shall represent them now? It may be much easier to answer a question of that kind than to preside over a distinguished society during an eventful period of its existence; and different people would, we fear, have different answers to offer. From the Society, as a society, there might be less difficulty in making an excellent choice, and about which there need be no heartburnings or humiliations. To illustrate our meaning we may mention for example, Sir F. Bolton, who was one of the principal founders of the Society, and who now occupies a position which places him above the suspicion of rivalry and outside the range of jealousy. We name him only by way of indicating the sort of President the Society requires for the coming year, and of escaping some of the personal and professional difficulties which otherwise may lead to the election of a President not in all respects desirable for an occasion like that with which the SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS will have to deal.

PROPOSED ATLANTIC CABLES.

Twenty years ago, in July, 1866, the shores of the Atlantic were permanently linked, and since that time the Old and New Worlds have been in communication with each other. Two months later, in September, 1866, the second link was completed. At the end of twenty years no less than ten cables are at work underneath the waves of the North Atlantic, and we have been somewhat surprised during the past week to see a new company announced having for its object the laying of other cables across the Atlantic. We should be glad to be able to say that the progress of twenty years had been so rapid that the capabilities of existing cables were tested to the utmost; but, unfortunately, the contrary is the case, although at the present moment the rates are very low. The capacity of existing cables is far in excess of the requirements. The investing public require to have this fact very clearly set forth, so that they may, putting the glamour of prospectuses aside, be able to judge as to the suitability of the investment. The total telegraphing business across the Atlantic is not difficult to ascertain. The managing director of the Anglo-American Telegraph Company, in a letter to *The Times*, gives the total amount at the 6d. per word tariff as £300,000, and we have no reason to suppose that he is in error. The new company does not propose to offer any greater facilities to the telegraphing community than the existing cable companies offer, and therefore in the nature of things it cannot expect to do more than get a moderate share of the business. Why a new company should get any business is difficult to understand in face of the fact that any business must be from the clients of the other concerns, to whom no inducement for change is offered.

We will now deal with the question of capital, which as dealt with in the prospectus is somewhat misleading. It is said that the existing companies, with ten cables, have a capital of about £14,000,000. That is so from one point of view—the balance-sheet—and only from that point of view. The investor's point of view is, What will £100 stock cost? And if £100 stock costs £40, the concern paying 2½ per cent., it really means that the investor gets something like £5. 12s. 6d. per cent. on his investment. In other words, it makes little difference what the capital is *said* to be, the vital point is its market value. Now, the market value of shares in Atlantic Cable companies is not an inviting one. They stand at a heavy discount, probably, taken all round, at more than 50 per cent. The market value, then, of the paper capital is less than half that stated in the prospectus. But, after all, what does it matter as to market or paper value if, at the existing rates, *no dividend is earned?* The capital might as well be £0. 0s. 0d. as any other amount. We should be delighted to be able to support new schemes of this kind, inasmuch as if the cable companies were in a prosperous condition it would also mean that the general trade of the country was more or less prospering. Even with increased business it is evident that cables cannot be worked remuneratively at too low a tariff. We have not entered into this question in any but a general manner, as we think the investing public is too familar with the existing state of the cable companies to venture into a new concern with almost absolute certainty that all the conditions are unfavourable to its success.

CORRESPONDENCE.

THE CHARACTERISTICS OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Bosanquet, in his letter to you under the above title, claims to have already, four years ago, developed a theory of magnetic circuits having substantially the same outline as mine. I have not the slightest wish to enter into a dispute as to priority, and am perfectly willing to admit that Mr. Bosanquet, Prof. Rowland, and many more have studied the magnetic circuit long before me. But allow me to ask your correspondent why he did not apply his investigations to the practical purpose of teaching us how to design dynamo machines? Had he done so four years ago, I and many of my professional colleagues would have been extremely grateful to him. It is all very well to write highly scientific papers for the Royal Society; but I claim that it is still better to write and publish in such manner that those who run (in the race of practical development) may read and learn; and I hope in future Mr. Bosanquet will give us the benefit of his scientific investigations immediately they have resulted in practical formulæ, and thus secure his claims of priority in an unmistakable manner.

The units I employ are a terror to him, and he actually requires the use of logarithms to work out the ratio of 6,000 to the number of square centimetres in a square inch. He evidently thinks that, since the scientists have settled that the C.-G.-S. system is the basis of their calculations, it is very wrong of me to employ another system of measurements. My defence is that units of measurement are simply a means to an end, and that such units will be best for practical work which fit in with the measures employed in our engineering shops. I for one should be very glad if the metrical system were adopted throughout the English engineering profession, but until this

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is the case it would obviously be impossible to talk to our workmen of centimetres and grammes. The drawing of a dynamo must therefore be dimensioned in inches, and the weights must be given in pounds or cwts. Mr. Bosanquet will, I think, agree to this; and the question is therefore narrowed down to the following:—Should our calculations be made in a different system of measurement from that of the working drawings? I am strongly opposed to such practice, because each change of units increases the probability of error. Moreover, with the units I use the figures are all of reasonable magnitude, and therefore within the power of conception of an ordinary engineering mind. Can the same be said of the C.-G.-S. system? The figures are so large that it is difficult to form a correct idea of their magnitude. Is it not easier to say "the total useful field of this dynamo contains two thousand lines," than "one million two hundred thousand lines?"

Mr. Bosanquet is curious to know how I measured the magnetised section in my wire armature, which he considers a matter of the greatest difficulty. The question is strange because of its very simple solution, but as it would be discourteous to leave it without an answer I will just mention that for the purpose of such measurements I generally employ an instrument familiarly known as a "two-foot rule," and having ascertained the area filled by wire I multiply it by the ratio of π to 4, in order to allow for the waste space between the wires. When discs are employed I clamp an equal number of naked and insulated discs in a vice, and ascertain the ratio of space occupied by insulation by direct measurement.—Yours, &c., GISBERT KAPP.

[We are glad to welcome Mr. Kapp's protest against the C.-G.-S. system, and trust that others may follow his example. We have long held that the C.-G.-S. system is out of place in the workshop, and shall heartily support any movement towards a suitable system.—ED. *E.*]

SECONDARY GENERATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: During the year 1882, being then in Boston, Mass., I carried out a series of experiments upon the use of the induction coil for the purpose of supplying electrical energy from central stations. As a result of these experiments I made an application to the United States Patent Office. The application was filed on the 29th January, 1883, and contained a complete description of a system, in which alternating or undulating currents of high tension, generated in a central station, are used in combination with induction coils, which transformed the electric energy conveyed by the mains into a number of currents of low tension and large quantity. Various arrangements were described and shown in the drawings.

The substance of this rather lengthy application may best be seen from one of its claims, which reads literally as follows:—

"The combination in a system of electrical distribution of a generator adapted to produce electric currents of high E.M.F., a continuous conductor, including the primaries of a series of inductoriums, and forming an internal circuit for the said generator; and a series of secondary circuits, each including one or more electric lamps, and formed of the secondary circuits of the said inductoriums, whereby the high-tension currents flowing in the main conductors and primaries are enabled to develop secondary currents of low tension and great volume in the secondary circuits, substantially as and for the purpose described."

The application was rejected, and the objection of the Patent Office commenced as follows:—"Applicant should demonstrate more clearly to the office the possibility of producing quantity currents from intensity currents by means of an induction coil; it is not apparent how applicant in any case can get more quantity from a secondary coil than he has in his primary."

I now find that a patent has been granted to Messrs. Gaulard and Gibbs on the 26th October, 1886, of which the first claim reads as follows:—

"(1.) The hereinbefore described art or method of electrical distribution and conversion, which consists in establishing in a closed electric current a current of alternate and equal positive and negative potential, producing by the influence of such current an inductive field of alternate polarity, and thereby inducing in translating devices situated in an independent closed circuit traversing such field a similar alternating secondary current of greater quantity and less potential than the originating or producing current."

I do not see any material difference between the claim which was refused to me in 1883, and that which is granted to Messrs. Gaulard and Gibbs in 1886. It is quite apparent that the examiner in 1886 had a clearer view of the function of an induction coil than was the case in 1883.

I may also mention that in my experiments at that time I made use of a continuous iron core for the induction coil.

Although I am quite willing to acknowledge the merit of those who have in the meantime brought this system into practical application, I do suppose that I am entitled to all those rights which are due to me on account of priority in invention.—Yours, &c., ALEXANDER BERNSTEIN.

The Bernstein Electric Lamp Company (Limited),
9A, Commercial-road, London, S.W., Nov. 20, 1886.

INCANDESCENT LAMP MANUFACTURE.

BY J. SWINBURNE.

Perhaps nothing so simple is so little understood as the incandescent lamp. It is merely a piece of carbon enclosed in a globe with the air pumped out; yet it costs 5s., without any obvious reason, and the cost of electric lighting is more than doubled by people not knowing how to run their lamps properly.

As no full account of the manufacture of incandescent lamps has yet appeared, it is hoped an attempt may be welcomed not only by those who are already engaged in lamp manufacture, but also by those whose success depends on their proper use, and by the large class who take an interest in a manufacture that involves so many branches of applied science.

It is the policy of incandescent lamp makers to keep their processes and modes of manufacture as secret as possible. At first this was, no doubt, very good policy on their part, but it is questionable if it does them much good now. The result of it is that each maker has to go through a number of tedious and very expensive experiments, which might have been saved. Moreover, the secret processes so jealously guarded are probably much the same in different factories, and the success of a lamp maker must soon depend, not on secret processes but on good business management, not only in making but in selling his lamps. The present high price of lamps is not due to labour in making but to superintendence, to waste through manufacture of bad lamps, which are or are not sold, and to bad business management and waste of money generally. In addition, large sums have often been paid for patents of doubtful value.

There is no exception in the case of incandescent lamp making; it has to go through the same vicissitudes as other branches of electric lighting. We blame the Electric Lighting Act, as it is a very convenient scapegoat, but the slow progress of electric lighting is mainly due to our own incapacity, not to legislation or to speculative companies. Electric lighting, as a new business, needed men who had technical knowledge as well as business capacity; and even now, after four or five years' work, an electrical engineer knows less about his work, in proportion to the position he holds, than most other professional men. This, of course, is unavoidable in a new industry. To begin with, electrical businesses had to be managed by men who were either scientific and unbusinesslike or businesslike and unscientific; much was done by people who knew nothing either of science or business. The result has been that what may be called electric light management has arisen, its most obvious features being great hurry with no speed, great expectations with no reason for them, and generally doing everything at night that should be done in the day. The industry is looking more promising

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now, as electricians are gradually acquiring business habits, and business men see that it is necessary to be technical also.

Incandescent lamp making is the most purely scientific branch of electric lighting, and it has therefore suffered most from unbusinesslike management. It is probable that lamps will gradually fall in price during the next few years as lamp factories are better managed. These articles cannot, unfortunately, give any useful information on the subject of management; but it is hoped they may be found of technical value to lamp makers themselves. Of course every lamp maker thinks he, and he alone, knows how to make lamps; but though each manufacturer knows a great many things unknown to other people, he is also ignorant of many things known to almost everyone else. It will be the writer's endeavour, therefore, to give as full an account as possible of what he knows and of what he has found in his own experience. This cannot but tend to help lamp makers out of some technical difficulties, and to reduce lamp making to its proper level of a commercial manufacture with legitimate profits. Electric lighting may be said to be on a firm basis when people give up inventing and substitute designing; lamp making when success depends on well organised manufacture, not on patents or processes.

As the writer can only describe what has come within his own experience, it must be understood that when he writes about his own processes and apparatus, it is because he knows them best, not because they are in universal use or particularly good.

History.

It is unadvisable to write a history of the incandescent lamp here, for several reasons. In the first place, this is not an encyclopædia article; and, in the second place, the history of the incandescent lamp is to be found almost word for word in the numerous books on electric lighting published in England and on the Continent. One of the best accounts is in "Electric Illumination," by James Dredge. The idea of using a thin carbon in a vacuum for lighting is at least half a century old. About 1836 the question of lighting mines more safely seems to have occupied great attention in Belgium. It was then proposed to use carbon in a vacuum. It is very difficult to find out much about what was done in those early days, as papers of that date are not easily got. The earliest mention of incandescent lamps seems to be in the *Courier Belge* of 1836, quoted by Louyet in the *Comptes Rendus*, 1846, page 225; "*Nous voulons parler de l'incandescence de charbon produite dans le vide au moyen d'une pile voltaique.*" It appears that De Changy took the matter up soon after, and he seems to have worked both with platinum and carbon, but to have been more successful with platinum. It is difficult to find out much about De Changy's lamps. Most of the accounts of electric lights in those days are too vague and exaggerated to be of much use now. It seems, however, from a technical account that appeared in one of the French journals, that De Changy's lamp, as exhibited, was a platinum lamp. The next period of activity in electric lighting was between 1845 and 1855. Anyone interested in the history of lamps will find many accounts in the *Mechanics' Magazine* of that time. The electric light seems even then to have been a mere curiosity, useful for displays, or for astonishing fish, but the cost of primary batteries prevented its commercial use as an illuminant. Any further information can be got from the excellent article in "Electric Illumination" already mentioned. The incandescent lamp was not invented by anybody. It was a gradual growth, like the arc lamp; and immediately the dynamo became a commercial success, and the incandescent lamp was wanted, it was forthcoming. Those who have studied not only the arc lamp patents but the electrical patents generally of forty years ago must see that very little new has been brought out during the last six years; the only thing wanted to make both arc and incandescent lighting a success even then was a commercial demand for it. If credit is due to any one for the introduction of the incandescent lamp it is to Swan, Lane-Fox, and Stearn for doing the work, and to Edison for making a noise about it. There are, no doubt, many subordinates who have done good work, but whose names naturally do not come before the public; such, for instance, as Mr. F. Topham, Mr. Stearn's ingenious assistant. Incandescent lamp makers are also indirectly indebted to Mr. W. Crookes for his work on high vacua. It is probable that incandescent lamp makers, though they may be unable to tell scientific men much about very high vacua, may be able to show them how to make very much simpler and better pumps than those used in the laboratory; yet this is but a slight return to Sprengel, Geissler, and Crookes.

Preparation of the Carbon.

The first quality necessary to a carbon is that it should be durable at high temperatures in a vacuum; the second that it should be easy to make; and the third that it can be made of any size, surface, or resistance that may be required. The commonest cause of failure is not, as might be supposed, the first, but the third. People have often made a few lamps in the laboratory, and concluded that they have invented a lamp, and that there is nothing further to do but to make it in large quantities. The disappearance of the numerous lamps that have been brought out one after the other during the last few years is mainly due to the impossibility of making them wholesale. The inventor who has made a few dozen lamps with some new form of carbon, so far from having done his work, has only just begun it, and, as likely as not, has begun it wrong. He afterwards has to invent or design apparatus for manufacturing on a large scale with uniformity.

The different forms of carbon may be subdivded and treated separately. The various kinds commonly used may be classified as:—

Retort carbon, or carbon deposited from gaseous hydrocarbon by heat.

Vegetable carbon of organic structure, such as carbonised paper, bamboo, roots, scrubbing brush bristles, &c.

Amyloid, as used by Swan, Weston, and the Anglo-American Brush Corporation.

Animal, such as silk, catgut, &c,

Chemically deposited, as Smith's.

There are a few varieties not included in the above list, but they can be described separately.

BRITISH ASSOCIATION, 1886.

The following papers marked * were contributed to the late meeting of the British Association on various subjects connected with Electrolysis.

PROF. BOUTY ON ELECTROLYTIC CONDUCTIVITY.*

(*Concluded from page 35*).

In all these cases one may notice that *electrolytic reactions which go on for the most feeble currents absorb always less heat than those which occur with stronger currents.* This extension to mixtures of the beautiful law announced by Berthelot for the case of electrolysis of a single salt is confirmed by a study of particular cases. For instance, the following table sums up the author's observations on a mixture of $\frac{9}{10}$ by volume of a solution of Na_2SO_4, and $\frac{1}{10}$ of a solution of $CuSO_4$, both pure and saturated when cold. The polarisation of anode is so small as to be negligible; the polarisation of cathode is given for various intensities of current in ten-thousandths of an ampere per square centimetre.

Current Intensity.	Polarisation of Cathode in Volts.	
7	·042	Brilliant deposit of copper.
10	·044	
15	·045	
19	·051	
31	·068	
36	·100	
41	·162	
44·7	·298	
45·4	·859	Brown deposit.
77	1·366	
150	1·585	Abundant evolution of hydrogen

The brown deposit of oxide appears as soon as the polarisation exceeds ·28 volt. The polarisation increases first very

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rapidly, then slowly, and its limit is very nearly the number (1·428 volt) which corresponds to the decomposition of Na_2SO_4 between copper electrodes. (It is slightly sophisticated by the extra resistance of gas bubbles then given off.) To sum up: First is decomposed $CuSO_4$, which theoretically consumes no energy (the electrodes being copper), then comes in the decomposition of acid water (·28 volt), finally that of sulphate of soda (1·424).

As for the conductivity of the mixture, it remains perfectly invariable in spite of the variability of the electrolytic reactions.

M. Bouty then quotes a saying of Wiedemann, that from a mixture of any of the following metals, Zn, Cd, Pt, Cu, Ag, Au, any metal which follows in the list is deposited to the exclusion of any which precedes. This is manifestly in accord with the above law, for the metals are in order of thermal equivalents. But the fact is only true for feeble currents. With strong currents a mixed deposit is obtained.

To sum up: *Liquids have, like metals, only one mode of conducting electricity. Also, they have, like metals, only one contact E.M.F. with an electrode of invariable composition.* But the result of electrolysis being to modify both electrode and liquid round it, their contact E.M.F. alters in a variable manner—whence polarisation.

SUR LA CONDUCTIBILITE ELECTRIQUE DES DISSOLUTIONS SALINES TRES ETENDUES.

By M. E. Bouty.* Abstract by Oliver Lodge.

I. *Historical.*

"The electric conductivity of salts dissolved in water varies with concentration in a manner extremely complex and differing for different salts. One possesses neither general law nor empirical formula, of however limited an application. One conceives *à priori* that this conductivity depends on the chemical nature of the salt, on the hydrates it can form, and on their stability; experience establishes also that it is not without relation to some physical properties of the solution, in particular its viscosity. But the separation of these circumstances has not yet been made. There seemed to me room first to simplify the problem by considering only solutions of identical physical properties. I have therefore chosen solutions so dilute that their density and viscosity are the same as pure water; their conductivity is yet relatively enormous, and can be measured easily by an electrometric method derived from that of M. Lippmann,"

In this method, as now applied, the tapping electrodes are zinc in sulphate of zinc, communication being established between the experimental fluid and the sulphate of zinc by a pair of capillary openings in the experimental tube. The difference of potential between these tapping electrodes is either measured by a Lippmann electrometer and compared against another difference taken at the ends of a known wire in the same circuit, chosen so as to be as nearly equal in resistance to the liquid as possible; or, what is plainly better, it is compensated by an auxiliary wire, and the electrometer brought to zero.

The author quotes Kohlrausch's views as expressed in his paper in Wiedemann's *Annalen*, VI., pp. 1, 51, 145, 210; but he objects to them as founded too much on extrapolation, the conclusions being stated for extremely dilute solutions, while those experimented with contained $\frac{1}{20}$th of their weight of salt. "So, although my results present a general agreement with those of M. Kohlrausch within the limits in which he has himself worked, I find myself led for their interpretation to conclusions absolutely different from that of the learned German professor."

II.—*Method of Measurement.*

The liquids to be compared are contained in two long vertical inverted U tubes, dipping with their open ends into two pairs of porous pots, each pair full of the same liquid as is in its tube. The four pots, and also the two main (zinc) electrodes, are contained in six separate glass vessels, all full of sulphate of zinc solution, connected up by short stout siphon tubes, as shown in Fig. 1. The tapping electrodes are zinc blocks, each in a Woulffe's bottle of sulphate of zinc, with a projecting and recurved full tube able to dip into any part of the liquid in the glass cells outside the porous pots, and so make connection (*see* Fig. 2).

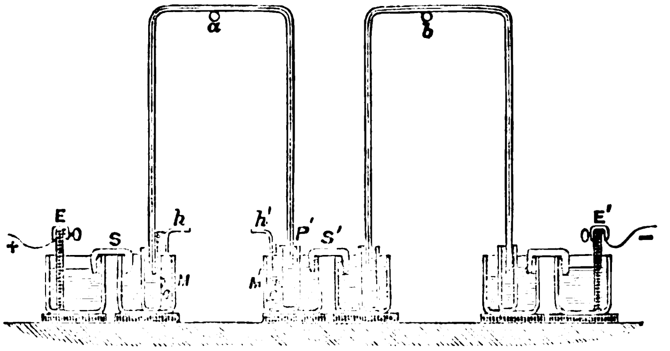

Fig. 1.

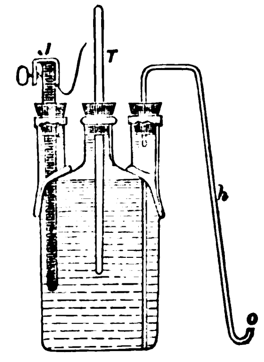

Fig. 2.

After taking readings for the two tubes filled with different liquids, they are both filled with the same liquid and fresh readings taken, so as to compensate for inequalities between the tubes.

III.—*Conductivity of very dilute Neutral-salt Solutions.*

"When one takes a solution of a neutral salt, already pretty dilute, and doubles the quantity of water it contains, the specific resistance is in general far from being doubled, as one would *à priori* expect; it is multiplied by a coefficient λ, smaller than two, which increases progressively with dilution and tends towards the limit 2, but only for excessive dilution. Here, for example, are some numbers furnished by sulphate of zinc:—

Initial concentration	*Ratio λ.	Initial concentration.	Ratio λ.
$\frac{1}{10}$	1 684	$\frac{1}{160}$	1·752
$\frac{1}{20}$	1·712	$\frac{1}{320}$	1·805
$\frac{1}{40}$	1·721	$\frac{1}{640}$	1 845
$\frac{1}{80}$	1 739	$\frac{1}{1280}$	1·953

Chloride of potassium gave in one experiment:—

Initial concentration.	Ratio λ.	Initial concentration.	Ratio λ.
$\frac{1}{30}$	1·921	$\frac{1}{240}$	1·933
$\frac{1}{60}$	1·943	$\frac{1}{480}$	1·958
$\frac{1}{120}$	1·931	$\frac{1}{960}$	1 945

* This "ratio λ" is plainly the same thing as Arrhenius' "exponent of dilution," only more simply introduced. I have shown in remarks on Arrhenius' memoir (first part) that the meaning of this "ratio λ," in so far as it is constant, is that conductivity varies as a power of the concentration, $k \propto m^r$ where $r = \log \lambda / \log 2$.

"Anhydrous salts behave in general like KCl, that is to say, the ratio λ is very near 2, even for moderate concentrations. Hydrated salts, on the other hand, are comparable to sulphate of zinc, and it is only for very great dilutions that their ratio λ approaches the value 2."

M. Bouty considers that at sufficient dilution the molecular conductivity of all salts is the same. For salts without water

* *Annales de Chimie et de Physique*, 6e série, 1884, T. III.; also *Journ. de Phys.*, 2e série, T. III., p. 325. See also Foussereau, *Journ. de Phys.*, T. IV.

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of crystallisation a concentration of $\frac{1}{1000}$ or so may be permitted; but for hydrated salts it is necessary to go below these limits, a thing *which requires the possession of absolutely pure water*, and he is only able to show that they approach equality to the other class of salts when very attenuated. Two tables follow, showing ratios of resistances compared with ratios of concentration, first for anhydrous salts, and then for salts which crystallise with a definite amount of water, KCl being taken as the standard of reference.

(*To be continued.*)

SOCIETY OF TELEGRAPH-ENGINEERS—Nov. 25th.

Prof. HUGHES, F.R.S., President, in the chair.

After reading and confirming the minutes of the last meeting, Prof. G. FORBES continued the discussion on Mr. Kapp's paper, "On the Pre-Determination of the Characteristics of Dynamos," read at the meeting held on November 12th. Prof. Forbes, in the first place, referred to the work of previous writers, and particularly that of Frölich as the initiator of this subject; also to Prof. Rucker; and especially to the paper of the Bros. Hopkinson, read before the Royal Society. With regard to Mr. Kapp's paper, he objected most emphatically to the nomenclature and notation employed as leading to a great waste of brain power, and rendering the argument much more difficult to follow except to those who had plenty of time to spare. For himself, owing to Mr. Kapp adopting such mixed notation, he had been unable to work out some parts of the paper, and for the same reason he imagined that several of the conclusions were erroneous, although by a happy selection of constants the curve ultimately obtained was practically that required. Owing to Mr. Kapp's paper, read last year before the Institution of Civil Engineers, many students had probably turned their attention to the subject, which may shortly be stated as the ratio of waste to useful lines of force in the dynamo. Prof. Forbes went on to describe his own work n this direction, and pointed out that waste lines of force or leakage was calculable, and that he had calculated such lines by adopting three formulæ, or lemmas, one or other of which was applicable to each case of leakage. He took the first source of leakage as between the ends of the poles; the second source across the limbs of the field magnets: this source he divided into (α) direct leakage across; (β) leakage from the sides of the limbs: third source, leakage from the sides of the pole-pieces; and fourth source, from the backs of poles to ends of yoke. The most important portion practically of Prof. Forbes' criticism was at the conclusion, when he took exception to the idea that there must of necessity be waste lines of force in dynamos. He did not see why those waste lines should exist to any appreciable extent, and suggested for the consideration of practical men that the present system of winding was wrong. It is not the field-magnets that we want to magnetise, but the armature; then why not magnetise the armature directly by winding the copper so as to directly, and not indirectly, magnetise it? Prof. Forbes illustrated his suggestion by means of a diagram, and said that although difficulties might arise and the winding be in the way of the commutator, the difficulties of such winding ought not to be insuperable.

Dr. HOPKINSON said that during the discussion which had already taken place, much time had been devoted to the analogy of electric conductors with the subject dealt with by Mr. Kapp. For his part, he thought it better to set aside analogies, and examine the ascertainable facts. We had, it is true, a convenient law in relation to electrical conduction; but we know perfectly well it does not hold good for iron. Magnetisation is a function of exciting power, and as such we had better treat it rather than trouble to find its analogy with conductivity. He agreed with Prof. Forbes in his objections to the system of measurement adopted by Mr. Kapp, and in the expression of a desire that he would adopt the C.-G.-S. system. Turning to the subject of the magnetic field, Dr. Hopkinson stated that his brother and he had not attempted to calculate it in the manner suggested by Prof. Forbes. Still it was remarkable that that gentleman should have arrived at results so close to their own by a method totally different. Judged by his, Dr. Hopkinson's, experience, some of the figures said to have been obtained by Mr. Kapp were startlingly high; but he could not presume to question them further than that. He also concurred with Prof. Forbes in recommending the institution of careful experiments to be made into the magnetisation of iron, some of which he indicated. He concluded by paying a high compliment to Mr. Kapp, who had independently, and by his own unaided efforts, obtained results which were extremely valuable.

Dr. FLEMING said that it was essential to recognise that no algebraical formula could fully express the function of magnetisation. At the same time it was interesting to take Frölich's expression and compare it with the results obtained by Mr. Shelford Bidwell, when employing very high magnetising forces. Fröllich's formuia might be interpreted to mean that the reciprocal of the susceptibility of the iron to magnetisation is a linear function of the magnetising force. Now, Mr. Bidwell's curves distinctly showed this linear relation for magnetising forces between 10 and 600 C.G.S. units. But below 10 units the curve deviates very considerably from the straight line.

After a few words from Mr. SIDNEY F. WALKER, Prof. S. P. THOMPSON showed that the true characteristic of the dynamo might be drawn from the "characteristic of magnetisation," as determined by the methods of Kapp and Hopkinson. As this cannot be made intelligible without the aid of a diagram, we are unable to give it in this issue.

After Prof. THOMPSON's remarks, the President announced that a special meeting of the Society would be held on Thursday next, when the discussion will be concluded.

DYNAMO-ELECTRIC MACHINERY.

BY J. HOPKINSON, M.A., D.Sc., F.R.S., AND E. HOPKINSON, M.A., D.Sc.

(*Continued from page 43.*)

Experiment to determine ν.

Around the middle of one of the magnet limbs a single coil of wire was taken, forming one complete convolution, and its ends connected to a Thomson's mirror galvanometer rendered fairly ballistic. If the circuit of the field-magnets, while the exciting current is passing, be suddenly short-circuited, the elongation of the galvanometer is a measure of the total induction within the core of the limbs, neglecting the residual magnetisation. If the short circuit be suddenly removed, so that the current again passes round the field-magnets, the elongation of the galvanometer will be equal in magnitude and opposite in direction.

The readings taken were:—

Zero..........................	71	left.
Deflection	332	,, magnets made.
,, ...	196	right; magnets short-circuited.
Hence, deflection to right =	267	
,, left =	261	
Mean deflection =	264	

To determine the induction through the armature, the leads to the ballistic galvanometer were soldered to consecutive bars of the commutator, connected to that convolution of the armature which lay in the plane of commutation.

The readings taken were:—

Zero..........................	23	left.
Deflection	223	,, magnets made.
,, ...	176	} right; magnets short-circuited.
,, ...	178	}
Hence, deflection to right and left .... =	200	

It thus appears that out of 264 lines of force passing through the cores of the magnet limbs at their centre, 200 go through the core of the armature, whence ν equals 1·32. The magnetising current round the fields during these experiments was 5·6 amperes.

Experiments on Waste Field not passing through Armature.

As in the determination of ν a single convolution was taken around the middle of one of the limbs, and connected to the ballistic galvanometer, the deflections, when a current of 5·6 amperes was suddenly passed through the field or short-circuited, were:—

Zero..........................	34	left.
Deflection	148	,, magnets made.
,, ...	82	right; magnets short-circuited.
Hence, deflection to right =	116	
,, left =	114	
Mean deflection =	115	

I. Four convolutions were then wound round the zinc plate and the cast-iron bed in a vertical plane, passing through the axis of the armature; and the deflections noted:—

Zero..........................	15	left.
Deflection	61	,, magnets short circuited.
,, ...	40	right; magnets made.
Zero..........................	11	left.
Deflection	64	,, magnets short-circuited.
,, ...	36	right; magnets made.
Hence, deflection to right =	55	
,, left =	46	
and deflection to right =	47	
,, left =	53	

in the two observations respectively, given a mean = 50·25; or, reducing to one convolution, = 12·6.

II. A square wooden frame, 38cms. × 38cms., on which were wound ten convolutions, was then inserted between the magnet limbs, with one side resting on the armature, and an adjacent side projecting 5cms. beyond the coils on the limbs, or about 7·6cms. beyond the cores of the limbs. The deflections were:—

Zero	34 left.
Deflection	98 ,, magnets made.
,, ...	22 right; magnets short-circuited.
,, ...	21 ,, ,, ,,
,, ...	81 left; magnets made.
Hence, deflection to right =	56
,, left =	64
and ,, right =	55
,, left =	47

in the two observations respectively, giving a mean =55; or, reducing to one convolution, =5·5.

III. The same frame was raised a height of 6·35 cms. above the armature in a vertical plane. The deflections were :—

Zero	21 left.
Deflection	98 ,, magnets made.
Zero	35 left.
Deflection	8 right; magnets short-circuited.
Hence, deflection to left =	50
,, right =	43
and mean deflection =	46 5
or, reducing to one convolution =	4 6

IV. The same frame was again lowered on the armature and pushed inwards so as to lie symmetrically within the space between the limbs. The deflections were :—

Zero	32 right.
Deflection	112 ,, magnets made.
,, ...	48 left; magnets short circuited.

giving a mean of 80; or, reducing to one convolution, =8·0.

Let G represent the leakage through a vertical area bounded by the armature, and a line 7·6 cms. above the armature, and of the same width as the pole-pieces; let R be the remainder of the leakage between the limbs; then II. and III. give

$$\frac{2}{3}G+\frac{2}{3}R=5{\cdot}5 \quad \frac{2}{3}R=4{\cdot}6$$

whence $G=1{\cdot}35, \quad R=6{\cdot}9.$

Again IV. gives $\frac{5}{6}(G+R)=8{\cdot}0$

therefore $G+R=9{\cdot}6,$

which shows an agreement as near as might be expected, considering the rough nature of the experiment, and that the leakage is assumed uniform over the areas considered.

We take $G=1{\cdot}6 \quad R=8{\cdot}0$

Reducing these losses to percentages we have

$G=\frac{1{\cdot}6}{115}$	= 1·4	per cent.
$R=\frac{8{\cdot}0}{115}$	= 7·0	,,
And from I. the leakage through the zinc plate and iron base	= 10·3	,,
Hence the two gaps account for	2 8	,,
The zinc plate and iron base account for	10·3	,,
And the area between the limbs	7·0	,,
Making a total loss accounted for	20·1	,,
Out of an observed loss of	24·24	,,

The leakage through the shaft and from pole-piece to yoke, and one pole-piece to the other by exterior lines, will account for the remainder.

Effect of the Current in the Armature.

The currents in the fixed coils around the magnets are not the only magnetising forces applied in a dynamo machine; the currents in the moving coils of the armature have also their effect on the resultant field. There are in general two independent variables in a dynamo machine, the current around the magnets and the current in the armature, and the relation of E.M.F. to currents is fully represented by a surface. In well-constructed machines the effect of the latter is reduced to a minimum, but it can be by no means neglected. When a section of the armature coils is commutated it must inevitably be momentarily short circuited, and if at the time of commutation the field in which the section is moving is other than feeble, a considerable current will arise in that section accompanied by waste of power and destructive sparking. It may be well at once to give an idea of the possible magnitude of such effects. In the machine already described the mean E.M.F. in a section of the armature at a certain speed may be taken as 6 volts, its resistance 0·000995 ohm. Setting aside, then, for the moment questions of self-induction, if a section were commutated at a time when it was in a field of one-tenth part of the mean intensity of the whole field there would arise in that section, whilst short-circuited by the collecting brush, a current of 600 amperes, four times the current when the section is doing its normal work. The ideal adjustment of the collecting brushes is such that during the time they short-circuit the sections of the armature the magnetic forces shall just suffice to stop the current in the section, and to reverse it to the same current in the opposite direction.

Suppose the commutation occurs at an angle λ in advance of the symmetrical position between the fields, and that the total current through the armature be C, reckoned positive in the direction of the resultant E.M.F. of the machine, *i.e.*, positive when the machine is used as a generator of electricity. Taking any closed line through magnets and armature, symmetrically drawn as A B C D E F A (Fig. 4), it is obvious that the line integral of magnetic force is diminished by the current in the armature included between angle λ in front and angle λ behind the plane of symmetry. If m be the number of convolutions of the armature, the value of this magnetising force is $4\pi C\frac{m}{2}\frac{2\lambda}{\pi}=4\lambda mC$ opposed to the magnetising force of the fixed coils on the magnets. Thus, if we know the lead of the brushes and the current in the armature we are at once in a position to calculate the effect on the electromotive force of the machine. A further effect of the current in the armature is a material disturbance in the distribution of the induction over the bored face of the pole-piece; the force along B C (Fig. 4) is by no means equal to that along D E. Draw the closed curve B C G H B, the line integral along C G and H B is negligible. Hence the difference between force H G and B C is equal to $4\pi C\frac{m}{2}\frac{\kappa}{\pi}=2\kappa mC$ where κ is the angle C O G. This disturbance

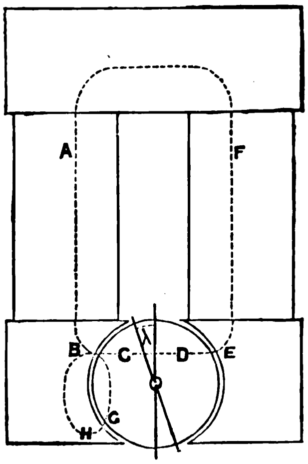

FIG. 4.

has no material effect upon the performance of the machine. But the current in the armature also distorts the arrangement of the comparatively weak field in the gap between the pole-pieces, displacing the point of zero field in the direction of rotation in a generator and opposite to the direction of rotation in a motor; and it is due to this that the non-sparking point for the brushes is displaced. A satisfactory mathematical analysis of the displacement of the field in the gap between the pole-pieces by the current in the armature would be more troublesome than *à priori* analysis of the distribution of field in this space when the magnet current is the only magnetising force. Owing to the fact that the armature is divided into a finite number of sections, there is a rapid diminution of the displacement of the field during the time that a section is being commutated, the diminution being recovered whilst the brush is in contact with only one bar of the commutator. The field thus oscillates slightly, owing to the disturbance caused by reversing the direction of the current in the successive sections of the armature. The number of oscillations in a Gramme armature or in a Siemens armature with an even number of sections will be ρm, where ρ is the number of revolutions per second, but in a Siemens armature with an odd number of sections it will be $2\rho m$.* This oscillation of the field is only another way of expressing the effect of the self-induction of the section, but it must be remembered that if the self-induction, multiplied by change of current, is expressed as a change in the field we must omit self-induction as a separate term in our electrical equations. The precise lead to be given to the brushes in order to avoid sparking in any given case depends on many circumstances—the form and extent of the pole-pieces, the number of sections in the armature, and the duration of the short circuit which the brushes cause in any section of the armature. The adjustment of the position of the collecting brushes is generally made by hand at the discretion of the attendant, and is in some cases fixed once for all to suit an average condition of the machine. We shall therefore treat λ the lead as an independent variable, controlled by the attendant.

Let I be total induction through the armature, I + I′ total induction through the magnets, I′ being the waste field. Let C be current in armature, c in the magnets. Let gI′ be the line integral of magnetic force from a point on one pole-piece to a point on the other, the line being drawn external to the armature, g will be approximately constant. Omitting as comparatively unimportant the magnetising force in the pole-pieces and iron core of the armature, we have the following equations :—

$$4\lambda mC+2l_2\frac{I}{A_2}-gI'=0$$

$$4\lambda mC+2l_2\frac{I}{A_2}+l_3f\left(\frac{I+I'}{A_3}\right)=4\pi nc.$$

* Added Aug. 17.—Armatures with an odd number of convolutions are open to one theoretical objection, which would be a practical one if the number of convolutions were very small. The $2m+1$ convolutions constitute in themselves a closed circuit, having a resistance four times the mean actual resistance of the armature measured between the collecting brushes. When any one convolution is exactly in the middle of the field the E.M.F. of the other $2m$ convolutions exactly balance, so that there is upon the closed circuit an E.M.F. due to the single convolution somewhat in excess of $\frac{1}{m}$th part of the actual E.M.F. of the machine. Thus there will be an alternating E.M.F. around the closed circuit of the armature capable of causing a considerable waste of power. This waste is materially checked by the self-induction of the circuit.

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When C=O we observed $I = \frac{1}{\nu - 1} I'$

whence $g = \frac{1}{\nu - 1} \frac{2 l_2}{A_2}$

eliminating I′

$$\frac{2 l_2}{\nu A_2}\left(\nu I + 4 \lambda m C \frac{A_2}{2 l_2} (\nu - 1)\right) + l_3 f \left\{\frac{\nu I + 4 \lambda m C . \frac{A_2}{2 l_2}(\nu - 1)}{A_3}\right\}$$

$$= 4 \pi n c + 4 \lambda m C \frac{\nu - 1}{\nu} - 4 \lambda m C = 4 \pi n c - 4 \lambda m C \frac{1}{\nu}.$$

The characteristic curve when C=O being $I = F(4 \pi n c)$ we may write the above as the equation of the characteristic surface thus

$$I + \frac{\nu - 1}{\nu} 4 \lambda m C \frac{A_2}{2 l_2} = F\left(4 \pi n c - \frac{4 \lambda m C}{\nu}\right).$$

In applying this equation it must not be forgotten that the E.M.F. of the machine cannot be determined from I unless the commutation occurs at such a time that the coil being commutated embraces all, or nearly all, the lines of induction in the armature.

This equation enables the characteristic surface to be constructed from the characteristic curve. Let $OL = 4\pi nc$, $LM = 4m\lambda C$. draw M K so that $\frac{KL}{LM} = \frac{1}{\nu}$, through K draw ordinate K R meeting characteristic curve in R,

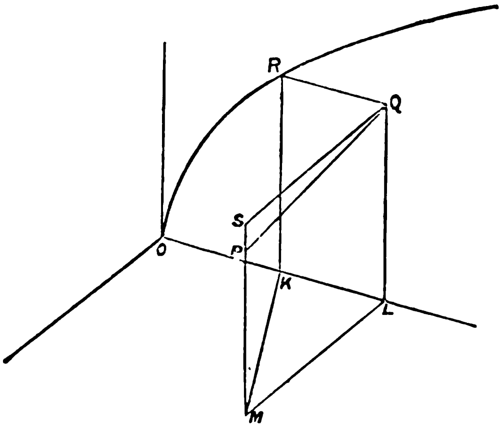

FIG. 5.

draw R Q parallel to O L meeting ordinate Q L in Q, draw Q S parallel to L M; draw Q P so that $\frac{PS}{SQ} = \frac{\nu - 1}{\nu} \cdot \frac{A_2}{2 l_2}$. Then P is a point on the characteristic surface.

(To be continued.)

LEGAL INTELLIGENCE.

The Direct Spanish Telegraph Company (Limited) *v.* Bannatyne.

On the resumption of the hearing of this case (which has been fully reported in recent issues of *The Electrician*) on Monday last, Mr. Rigby briefly recapitulated his arguments to show cause why the injunction granted by Vice-Chancellor Bacon should be overruled, concluding by reading the judgment delivered by the Vice-Chancellor.

Mr. P. BEALE pointed out that the question to determine was what was the real nature of the contract entered into with the preference shareholders by the light of the Act of 1867, and the special resolution passed in 1874, contending that there was nothing therein to show that, upon a reduction of capital, which the Company by that Act and their Articles were empowered to effect, the preference shareholders were entitled to any advantage over the ordinary shareholders. In this case there was no pretence that on a distribution of the assets or winding up of the Company the preference shareholders would get any priority. It was suggested that to refuse the injunction would be to establish a dangerous precedent, and enable directors to break the bargain they entered into with pereference shareholders. But what the Company proposed to do was simply to reduce the amount of the nominal capital unrepresented by assets, which was exactly the same thing as if by the Act of 1867 they reduced it by giving the holders half their money back. It was difficult to see, under Articles 7, 9, and 10, how capital could possibly be reduced if it were not to be reduced so as to put all the shareholders on an equality. The suggestion on the other side was to look at the position of the preference shareholders as if the Company were to grant them an annuity, but their lordships would agree that the Articles were not to be read in that way. In the affairs of an ordinary partnership would it not be perfectly right for the majority to be able to say, "We will deal with this by writing off the capital," just as they might say, "We don't want to use so much capital, we will return it?" There was a fair analogy between the company and an ordinary partnership. The reduction of capital was in reality very much like a winding up. They were only doing that which any prudent man of business would do when he lost his capital.

Mr. MARTEN, Q.C., said that, however much his learned friends might disguise it, the real effect of the resolution which had been passed would be to take money out of the pockets of the preference shareholders and put it into those of the ordinary shareholders. He contended that it was *ultra vires* on the part of the Company to pass any such resolution. As he understood it there could be no difficulty in the Court's determining the broad question whether or not capital could be reduced in the way proposed. That had been the question argued by Mr. Rigby and Mr. Beale: not whether it was competent for the Company to pass a resolution which contemplated the reduction of capital, by which the preference shareholders would be deprived of their dividends; and he asked their lordships to determine that question. The real question turned upon the construction of the three resolutions of 1874, and upon the construction of the circular which followed it. Those resolutions said: "That for effecting this purchase, and for other purposes of the Company, the Directors be and they are hereby authorised to increase the capital of the Company by the issue of 6,000 new shares of £10 each to be paid in full on allotment." "That such new shares should be entitled to a fixed preferential dividend of 10 per cent. per annum, and that if in any year the net profits of the Company should not be sufficient to pay the whole of such preferential dividend for that year, the balance should be paid (but without interest) out of the profits of the next year, and if need be of succeeding years." He submitted that that meant that the preference shareholders were always entitled to a fixed dividend of 10 per cent. on the capital they paid up, not with respect to the amount for the time being. The true construction of the bargain he thought had been put upon the documents by the learned Vice-Chancellor, who said that that was a bargain made once for all, and it would be doing violence to all ordinary understanding of language otherwise to construe it. Since the Act of 1877 was passed the other side said: "We can nullify that contract and reduce the capital, so that the money that was appropriated for your dividend will be put into the pockets of the ordinary shareholders." As the Vice-Chancellor pointed out, that would be a correct view of that which would happen if their lordships were to set aside the decision arrived at, and to introduce new elements never contemplated when the bargain was made. It was said that Section 10 of the original Articles authorised the reduction of capital, and that the special bargain should be subject to that.

Lord Justice COTTON pointed out that the Article referred to also said that power was granted to "alter the amount and denomination of its shares."

Mr. MARTEN contended that they could not alter the nominal amount of the shares of the bargain. No amount of alteration of the shares could alter the real bargain that the preference shareholders were to have a fixed dividend of 10 per cent. on their paid-up capital. They were entitled to an annuity of £6,000 a year, and the result of the resolution would be to take £3,000 of that away. Mr. Beale compared the passing of the resolution to the action of the majority in an ordinary partnership. The answer to that was simply that it was contrary to the original bargain to make use of the power they had to reduce capital for the purpose of benefiting one class of shareholders at the expense of the other. Put into plain English, the scheme came to this, that they were going to take £3,000 from the preference shareholders and hand it over to the ordinary shareholders. It would be a startling thing if the millions that had been invested in this country in preference shares could be treated in that way. and he submitted that the powers contained in Article 10, and the statutory power to reduce capital did not interfere with the bargain.

Mr. H. B. HOWARD followed, and remarked that there was nothing improper or *ultra vires* in the Company reducing their capital in the way they wished to do. There was no objection to that course so long as the preference shareholders received their £6,000 a year.

The Court then adjourned till Tuesday morning.

JUDGMENT.

On resuming, on Tuesday morning, Lord Justice COTTON said: This is an appeal from Vice-Chancellor Bacon, which raises a very important question. This Company, who are the defendants in this action, was formed in the year 1872 or 1873, and it had a capital, with power to add to that capital, and with power to give preference to any shares that might be created. Articles 7, 9, and 10 are the Articles which are most important. In 1874 resolutions were passed to increase the capital by 6,000 new shares, and those shares were to have a preference as regards dividend, but no preference as regards capital. They lost one of their cables, which, of course, was a loss of a considerable part of that which represented their capital. Resolutions were passed that they should reduce their capital by striking off half the nominal amount of each of the shares, both ordinary shares and preference shares, and then the injunction was granted by Vice-Chancellor Bacon, on the action of one of the shareholders who held preference shares as well as ordinary shares, and this is an appeal as against that injunction, the appeal, of course, being the appeal of the Company. Now, Articles 7, 9, and 10, to which I have referred, are these:—Article 7 is, "The Directors may, with the previous sanction of a special resolution of the Company, increase its capital by the issue of new shares to such an aggregate amount, with such preferential right to dividend and such priority in the distribution of assets, or subject to such postponement of dividends, or in the distribution of assets, as shall in such special resolution be provided." Article 9 is, "All capital raised by the creation of new shares shall be considered as part of the original capital, and shall be subject to the same provisions in all respects as if it had been part of the original capital, except so far as these Articles or the resolution authorising the raising thereof may otherwise direct." Section 10 is,

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"The Company may also, by special resolution, from time to time, reduce its capital and also alter the amount and denomination of its shares." Well, the Act of 1867 was then, of course, in operation, and this Article 10 must be regarded with reference to that Act; of course, it could not have been effectually done but for that Act, but we have got that in the Articles. In my opinion that is important to be considered in dealing with the question as to what was the bargain under which the preference shareholders took their shares. I think I need not read the resolution for diminishing their capital that was passed on the 30th September, 1886, after the Act of 1877 came into operation. Previous to the Act of 1877 there would be no doubt that what there was proposed to be done was sanctioned by Parliament, but, of course, one cannot look to that Act of 1877 for the purpose of considering what the bargain was under which the preference shareholders came in. On what ground is the injunction asked for? I need hardly refer to the Act of 1867, where there is in general terms power given to reduce the capital, preference capital being a thing then well known and very usual in companies under the Act of 1862, as well as in companies under the Companies Clauses Act; but that was general. How is it contended that the action of the Directors and Company under that Act, and also now under the Act of 1877, is *ultra vires*, beyond their power, and that it is to be restrained? Now, as regards its being beyond their power, I, myself, do not entertain any doubt that under those Acts it is authorised; but the question still remains as to whether it is contrary to the bargain which was made between the Directors and the Company and those who took their preference shares, and one must consider that question. It was contended, I think, though that probably was partly abandoned, that the existence of these preference shares showed that there was a separate contract that there could be no reduction of capital. That, probably, was afterwards abandoned, but still one must deal with the question. In my opinion that contention cannot prevail. The Act of 1867, as I say, deals generally with power to reduce capital, and the very Articles of Association in this case provide that the preference shares when formed shall be part of the capital. If there was a winding up, the capital being lost, wholly, or in part, the preference shareholders and the ordinary shareholders must bear the loss ratably between them, because, as I say, these shares were constituted without any preference as regards capital, though they had a preference as regards dividend. Then, if that is so, and there is a loss of capital, in consequence of which there is a reduction made in the capital of the Company by dividing the shares, by reducing the denomination of the shares, that must be borne not only by the ordinary shareholders but also by the preference shareholders, and it was really hardly contended ultimately that there could be no reduction of capital, in consequence of the existence of preference shareholders having a preference in dividend only, and not a preference as regards capital, which was to be returned or which was lost, and in consequence of that loss there was a reduction of the capital and a reduction of the amount of the shares. But then it is said that the contract in this case would be broken unless the preference shareholders still had the same amount of dividend as they now have. It was put in this way. It was said here, these shares (I will read the resolution) are constituted with a preferential dividend, being fully paid up, of 10 per cent. That is equal to £1 per share, and we must look at the matter as if there had been a contract to give them perpetually as long as profits could be in any way obtained, so as to provide them with an annuity of £6,000 a year. That was the argument, and that by what you are doing, although you might reduce the capital, yet you ought not to cut off any portion of that annuity of £6,000 a year. You may reduce the capital, if you in your resolution to reduce the capital provide that that annuity of £6,000 a year shall still be paid to the preference shareholders, though their shares are reduced from £10 shares to £5 shares. That, I think, was the argument. Now let us see what the bargain was. I may say that, for my own part, if there was a bargain which will be broken by the reduction of capital, I think that the plaintiffs, and the shareholders in the same position, would have a case not to destroy the powers of the Act of Parliament, but to prevent those who had contracted with them from breaking their contract and of applying the powers of the Act to prevent them using the powers given to them by the Act. They are powers given, and not duties imposed on the Company or its Directors. Here, what contract is there, and how would that be broken by what is proposed to be done? Now, it is this, that the Directors are authorised to purchase for the Company a new submarine cable. "That for effecting this purpose and for other purposes of the Company, the Directors be and they are hereby authorised to increase the capital of the Company by the issue of 6,000 new shares of £10 each to be paid in full on allotment. That such new shares shall be entitled to a fixed preferential dividend of 10 per cent. per annum," and then there is the right, if the profits in any year shall not be sufficient, to have recourse indefinitely to the profits in the following year. Well, now, it was practically not contended, and in my opinion it could not be successfully contended, that the second resolution providing that there shall be a new issue of new shares of £10 each, the contract therein contained would be broken by applying under the Act to reduce the shares, all of them, ordinary and special, from £10 shares to £5 shares. Is there any contract in the third resolution as to dividend which prevents this being done, or prevents it being done while the dividend which will be paid to the preference shareholders is 10 per cent. only on what will then be the amount of their shares? "Such new shares shall be entitled to a fixed preferential dividend of 10 per cent. per annum." It is very true that the 10 per cent. there will be 10 per cent. on what was actually paid on the shares; but, in my opinion, it is not £1 on the shares, not a dividend for ever of £1 on each share, or an annuity of £6,000 a year, but it is 10 per cent., and if for any reason the amount of the shares is reduced from £10 to £5—which will be the result if these resolutions for the reduction of capital are carried into effect—then the bargain, in my opinion, will be performed by giving the holders of those preference shares 10 per cent. on the then amount of their capital in the Company. They will, of course, have only half what they previously had, because their shares, or half their shares by reduction of capital, are reduced from £10 to £5 a share, and one must take into consideration this—that at the time when this bargain was made there was this special provision in the Articles, that the Company might from time to time reduce its capital and also alter the amount and denomination of its shares. In my opinion what has happened was not contemplated. I do not say that it was, because the loss of the cable which caused the loss of half their capital was a matter which they would not contemplate, but still those who make a bargain where the Articles have that provision and are in the terms which I have read, ought to know, if they considered the matter at all, that, although they took the shares of £10 with a contract that there should be 10 per cent., which so long as the shares were £10 would give them the £1 a share, that there was in the clause in the Articles a contemplation of its being necessary to reduce the capital, and therefore they ought to take that into consideration; and in my opinion also they ought to be considered as knowing and taking into consideration the provisions of the Act which then existed of 1867, which provided that a company limited by shares may, by special resolution, modify the conditions contained in their Memorandum of Association, and authorised so to do by its regulations as originally framed or as altered by special resolution as to reduce its capital. That, I say, is in general terms, which would apply not only to original non-preferential capital, but to any preferential capital; and, as regards the bargain here, Article 10 is clear to my mind that that would apply to any preferential shares which might be created, especially having regard to the previous Articles, which said they were to be considered as part of the original capital. It was contended that although there is now an Act of 1877, which renders it possible effectually to do that which the resolution proposes to do at the time when this bargain was made, there was only the Act of 1867 in operation, and that Act, it was said, had been decided not to enable this to be done, and that for that reason the Act of 1877 was passed. Now, of course, the law alters and changes rather, but so far as we can consider what was in the minds of the parties at the very time when this bargain was made by the issue of the new shares there was a decision that this could be done under the Act of 1867, and although the late Master of the Rolls, in the case of the Ebbw Vale Company, in January, 1877, did decide that it could not be done, yet the Act of 1877 did not recognise that as law, but merely, in order to remove doubts and difficulties, was passed as a declaratory Act, declaring what was the effect and operation of the Act of 1867. So far as anything in the minds of the parties was concerned, the decision as to the law as it stood in 1874 was that which alone they could regard, but I am by no means prepared to say that I think the view of the late Master of the Rolls, expressed in 1877, was the correct view. I should think that the Act of 1867 was quite wide enough of itself to enable what has now been done to be done; but as regards the understanding of the parties, in my opinion there must be looked to what was then declared to be law by, I think, Vice-Chancellor Bacon, and not to the doubt which was subsequently raised by the decision of the late Master of the Rolls on the true construction of this contract. In my opinion there is no breach of that contract by what the Directors propose to do, by diminishig the capital and allowing the dividend to still remain 10 per cent. on the then reduced amount of the shares. Now, I have entered into that for the purpose really of dealing with the questions which are in contest between the parties here, but if we could not hold that the mere reduction of capital and application to the Court to sanction that—one of the judges of the Chancery Division to sanction that—that would not be a breach of any contract, and in my opinion we could not really regard what the Directors propose to do in consequence of that reduction. If they were merely doing this, not honestly for the purpose of reducing capital, but for some indirect other purpose, that might be a question raised; but that is not raised, and though I think myself that the judge when he has to consider, under the provisions of the Acts of 1867 and 1877, whether he shall make an order sanctioning, is only required by the Act of 1867 to be satisfied that the creditors are duly protected, yet when he is satisfied of that, he only gets power to authorise the scheme which is proposed. The words are:—"He may make an order, confirming the reduction on such terms, and subject to such conditions as he deems fit." That leaves a discretion in him, and in my opinion, although it is not necessary to decide that point, I think the action fails, and the judge, when the matter is brought before him, if he sees it bears hardly on those who do not consent, may take that into consideration, and I think one ought not to sanction a scheme simply because the creditors, who must be looked to, are dealt with properly, and have no ground of complaint. I thought it right to express my opinion on that point, as the matter has come before us, and we have had the questions argued. I cannot think that when the words of the Act, "That he may make an order, subject to such terms and conditions as he thinks fit," render it obligatory on him to make an order confirming the scheme if those things without which he cannot act only had been done. In my opinion this action fails, and the injunction ought to be discharged. I should mention that the parties have agreed that this should be taken as disposing of every matter, without prejudice to their right of appeal; therefore the injunction will be discharged, and I suppose the action will be dismissed with costs.

Lord Justice FRY: In the year 1867 there was passed a statute which we have had to consider in this proceeding. That provided that any company limited by shares might by special resolution so far modify the conditions of its Memorandum of Association, and receive certain authority to reduce its capital. The words of that sub-section are very general, and it refers to any company limited by shares. It appears to me that, bearing in mind the fact that at the time that Act was passed the

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existence of the preference capital was a common and well known fact, and that the legislature must be taken to be dealing with the full knowledge of that fact, it is impossible to contend that a company limited by shares does not include a company some of whose capital may be preferential capital, and, in fact, I do not think that the contrary was argued in this case. Now, that being the enactment of 1867, what we learn from the authorities is this, that the course of practice under it enabled companies to diminish and reduce capital, although paid up. Such an order was made by the Vice-Chancellor Mallins in the case of the Muntz Metal Company in July, 1870, and a similar order was made by Vice-Chancellor Bacon in the matter of the Financial Company in January, 1871. As far as our attention has been drawn to the authorities, and as far as they are known to us—at any rate known to me—no doubt had been cast on the power of the Court to sanction the reduction of capital, although paid up before January, 1877. That being the state of the law as declared by Act of Parliament and by the authorities, this Company was registered in 1872. By the series of Articles of Association which deals with the increase and reduction of capital, the Company was authorised to increase its capital—to give a preferential right to these shares if the Company thought fit. It was declared that the new capital so raised should be considered as part of the original capital, and there was further an express power given to reduce the capital of this Company. Now, pausing upon these Articles of Association, it appears to me to be plain that the intention of it was to authorise the creation and the reduction of preferential capital. Then we next come to the special resolutions passed in July, 1874, when the state of the law and practice under the Act of 1867 remained as I have already stated. By the resolutions then passed preferential capital was created; each share consisting of £10 was to be paid up fully on allotment, and the third resolution provided that the new shares should be entitled to a fixed preferential dividend of 10 per cent. per annum. Now, the question which has been argued before us is this, whether or no those special resolutions do create a contract which excludes this Company from the right of applying to reduce its preferential paid-up capital. Now, having regard to the state of the law, and having, especially, regard to the Articles of Association with which these special resolutions must be read, it appears to me to be reasonably plain that the intention of the parties was that the preferential capital so to be created would fall under the operation of the 10th Article, and be capable of reduction. It seems to me to be reasonably plain that if it was the intention of the contracting parties to exclude that, the resolutions would have been very differently framed to what they are. They would be in such undoubted terms as to exclude that power. The language appears to me entirely opposed to any such contention as that which was addressed to us by the respondents because the right is a right to a fixed preferential dividend of 10 per cent. per annum. But on what? Obviously, it seems to me, on the amount of the shares, those shares being, as I have already stated, according to my view of the true construction of the instruments, subject to the power of reduction. The contention of Mr. Marten was, it seems to me, a rather extraordinary one. He did not deny the right of the Company to reduce the preferential capital, but he maintained if the preferential capital were reduced the preferential dividend must be proportionately increased, so that that should be a consonant. That would violate the very words of the resolution, which fixes the preferential dividend not at a given sum, but at a certain percentage on some other sum which is not expressed in the resolution. That is an entirely untenable contention. I think, therefore the true view of the bargain between the parties was this, that the preferential capital was created subject to the right of reduction which was expressly provided for in the Articles of Association. There are no words, no indication whatever, in those resolutions to exclude the power so expressly given to the Company. It appears to me not necessary to say any more on that. That determines one of the necessary propositions on the part of the plaintiffs adversely to them. Various other questions have been referred to, and more or less discussed, during the argument. I am far from expressing any difference of opinion in the view which Lord Justice Cotton has enunciated, but I do not express my opinion on the question how far it is possible by contract to exclude the right of applying to the Court under the Acts of 1867 and 1877, or how far the jurisdiction of the Court and the exercise of the jurisdiction under those sections is discretionary, or how far it is proper for the Court to consider the contract between the preference and other shareholders in determining whether they shall or shall not approve of the reduction. I do not express any opinion on those points, because they have not been fully argued, and although I express no dissent from what has been said by Lord Justice Cotton, I think it safer for myself, to consider they are still open questions. For these reasons I agree in the conclusion that this action must be dismissed, with costs.

Mr. Marten: As to the costs, will your lordship allow me to say that it appears that at the meeting the solicitor, speaking with the Chairman's permission, says, "It is extremely likely that some one will raise the question. I think I may say, with the Chairman's permission, that the Directors would not be sorry if some one would raise the question, as it would then make them perfectly clear, and save them from any anxiety in the future." What I submit to your lordships upon the question of costs is this, it is a matter which has arisen on the construction of the documents of the Company themselves, and also it was a matter on which the Directors suggested, through their solicitor, that they would be glad that there should be a decision, so as to make them perfectly safe in the matter. There have been contrary decisions, but the decision of the Court below was in our favour, and your lordships' decision against us.

Lord Justice Fry: Will they not be more glad, Mr. Marten, if you pay their costs?

Mr. Marten: No, my lord. What I should suggest is that the action should be dismissed without costs.

Lord Justice Fry: We cannot accede to that.

Cooks v. The Great Western Railway Company.

Lord Justice Cotton, in giving judgment in this case on Friday morning last, said that it was an appeal from the decision of Mr. Justice North, and was one of rather an extraordinary character. The action was first brought by gentlemen who were trustees of the Paddington estate, and occupiers of some of the houses there, and the object of the action was to restrain the Great Western Railway Company, who were also lessees of that estate, from breach of covenant which the plaintiffs alleged the defendants committed. When the case came on for hearing the railway company did not dispute that, and they submitted to the injunction. The injunction was not to be put in operation till the 19th of October, and it was practically to restrain a breach of the covenants, through the annoyance caused to the adjoining occupiers and owners of houses by the works for lighting with electricity the station and other portions of the Great Western Railway, near Westbourne-terrace. The plaintiffs moved, before Mr. Justice North, the previous week that a sequestration might be issued against the railway company, and his lordship did not refuse the application under certain circumstances, but made an order that the motion should stand over till the 11th of January. As he (Lord Justice Cotton) understood it, the judgment was on the basis that there had not been a compliance with the order of the Court—that was to say, that the defendants were guilty of a breach of the injunction, but the motion was made to stand over till the 10th of January. Against that there was an appeal, and it was extraordinary that there should be an appeal brought against the direction of a judge that the matter before him should stand for decision till a future period. The question was whether the judge was right in taking the course he did. The first question was whether the judge had discretion in such a case. Mr. Giffard contended that he had not—that it was the right of the plaintiff to enforce the order and to have the sequestration. That was, in his opinion, wrong, and, according to his interpretation of Order 42, Rule 31, as he understood Mr. Justice North's judgment, his lordship came to this conclusion, that there was a reasonable prospect on the evidence before him that by the time for which the order for sequestration was allowed to stand over had arrived the breach of the covenants would be remedied. He thought that was a proper mode for Mr. Justice North to exercise his discretion—whether on the evidence there was a reasonable prospect of the matter complained of being corrected by the railway company. When one looked at the nature of the case, before stopping the works of the railway company for lighting their station and adjoining works, one ought to consider alike the inconvenience to plaintiffs, and also the inconvenience and loss to the Company in stopping its works. Of course, if there had been wilful disobedience, he would not hesitate a moment in saying that the order must sternly be enforced—he meant wilful not in the sense in which it was used by Mr. Giffard, that every time they lighted their furnace they were committing wilful disobedience of the order, but an intention not to obey the order by removing the nuisance complained of. They had done what they could up to the present time to remove it. They had not, it was true, stopped their electric lighting, but they had done what they could to remove the nuisance. He ought to say that though he agreed in the course taken by Mr. Justice North, the railway company must not suppose that this Court would allow the order of the Court to be disregarded—that if there was no removal of the nuisance, or if there was no attempt to remove it, or if it turned out that it could not be removed, he would not for one moment suppose that the injunction would not be enforced. But was there the prospect which Mr. Justice North thought there was? Let them see what the matters complained of were, and whether there was any prospect of their being remedied. He would take first the smoke and steam. He himself was a little bit struck with the evidence as regarded the smoke and steam, because, as the matter was opened to the Court, it did not appear exactly how the getting the means of condensing the steam would remove the nuisance complained of caused by the smoke. It appeared, on the evidence, however, that the furnaces had been so constructed that they had the best contrivances for consuming their own smoke. The steam had not up to the present been effectually condensed. There was an effort to do it, but the chamber in which the steam was to be condensed was not made sufficiently strong, and after it had been two or three days in operation it had to be renewed. The company were taking, and he believed by this time had taken, very effectual means to construct a new chamber for the steam. How would that affect the smoke? It appeared that the amount of smoke escaping, although the furnaces were constructed according to the best method for consuming their own smoke was considerable. Even on the evidence, if there had not been sufficient provision for condensing the steam, that was what the Company were really trying their best to do; and as far as he could see there was every prospect that that would be done, as it undoubtedly could be done, and then both the steam nuisance and the smoke nuisance complained of would probably, as far as one could judge from the evidence, be remedied. Then as to the humming, which was one of the great complaints in the case. They had evidence that steps were taken before this motion was made to put a stop to the humming with a covering of wood, which, on the evidence, was very effectual. But the effect of raising the heat was to injure the coils in the dynamos, and therefore that would not answer. But according to the evidence the Company were taking steps to remedy the evil. The appellant's counsel treated what was being done as merely puerile efforts. He (Lord Justice Cotton) could not share that view. He was not an engineer, but there were many ways he should think by which the heating could be prevented. Having referred to the evidence of Sir Frederick Abel, Mr. Spagnoletti, and Dr. Hopkinson, his lordship thought there was every ground to suppose that the humming noise might be removed. Now, if suggestions were made which would, in the opinion of competent persons, remove the nuisance complained of, he would hesitate to order a sequestration without having an opportunity of seeing what those suggestions were, and of judging how far it could be said they were mere

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nonsense or child's play. Then, again, on the evidence there was certainly a doubt to his mind whether there was any vibration at all. In conclusion, his lordship added that in his opinion Mr. Justice North was right in the course he took, and, as he had stated already and would now repeat, the railway company had hitherto been doing their best to remove the nuisance complained of, and there ought at present to be no sequestration to delay them in carrying out the means which were contemplated. If those means were effectual, then there would be a compliance with the injunction ; but if it could only be complied with by the removal of the electric light, then, of course, they must submit to that course, as the covenant was broken by the machinery as it at present existed. In his opinion, therefore, the application failed.

Lord Justice FRY said he was entirely of the same opinion. He considered the appeal was ill-founded, and must be dismissed.

The ATTORNEY-GENERAL having applied for costs they were allowed.

Callow v. Young.

In the Chancery Division of the High Court on Friday, Mr. Romer, Q C. (with whom was Mr. Oswald), instructed by Mr. Herbert F. Oddy, of 58, Lombard-street, applied to Mr. Justice Chitty for a writ of attachment to issue against one Frederick Young for non-observance of an undertaking into which he had by his counsel entered. Mr. Romer said that Mr. Young was the defendant in an action "Callow and Young," which had been brought by Mr. Callow, who was carrying on business as F. Young and Co., telephone, telegraph, and bell case manufacturers at Clerkenwell Green, to obtain an injunction preventing the defendant from carrying on any such business within 100 miles of the Royal Exchange. Young had formerly carried on the business, and had retired in favour of Messrs. Heaton and James, with whom he entered into a covenant not to have anything to do in any way with any similar business. Mr. Callow, the plaintiff, bought the interest of Messrs. Heaton and James, but ascertained that the defendant Young had commenced business at Lloyd's Row, Clerkenwell, as a telephone, telegraph, and bell case manufacturer, under the name of Carrington, and that he employed Carrington as foreman, holding him out as the proprietor, but being himself the real proprietor. Upon these facts being represented to Mr. Justice Stirling, a perpetual injunction was granted against the defendant Young, with an inquiry as to damages and costs. The application now made was for a writ of attachment for a breach of the undertaking entered into by the defendant Young. The defendant had not been served personally because he could not be found, but his solicitor had received the customary notice that this motion would be made. There might be some difficulty about that, and out of extreme caution he thought it desirable it should be mentioned ; but after a short argument and references to the orders of the Court the learned judge said he would accept the service as good, remarking that there was a difference between giving a man a notice of a breach of a voluntary undertaking, and notice of an adverse order which had been made against him. Mr. Romer then read an affidavit which had been filed by Mr. Oddy, the plaintiff's solicitor, and also other affidavits, which went to show that the undertaking given by the defendant Young had been broken by his setting up business under cover of Carrington's name, at Lloyd's-row, Clerkenwell.

Mr. Justice CHITTY said that that was sufficient to prove the plaintiff's case, and granted leave for the issue of a writ of attachment for the arrest of the defendant Young, with costs against him.

THE BLACKPOOL ELECTRIC TRAMWAY COMPANY.

The report of the Directors of this Company for the year ending 31st October, 1886, was issued on the 19th inst. The second annual meeting of shareholders is called for to-morrow (Saturday), at three in the afternoon, and the report runs as follows :—

The revenue account shows the sum of £5,125. 17s. 3d. as receipts, and £3,334. 14s. 7d. as working expenses, or a balance of profit for the year of £1,791. 2s. 8d. Adding to this £62. 7s. 6d. from last year in respect of the period from the opening (12th September) to 31st October, 1885, makes an available amount of £1,853. 10s. 2d., of which the Directors recommend the following appropriation :—

A dividend of 5 per cent. on £20,025 (the called up capital of the Company)	£1,001	5	0
Depreciation and reserve fund	800	0	0
Balance to next year	52	5	2
	£1,853	10	2

The Board consider the above result of the first full working year of the Company as satisfactory. Three directors, taken in alphabetical order, under the Articles of Association, retire at the meeting, viz.:—Messrs. Morris, Moseley, and Oddie, who are eligible for re-election. Dr. Scholefield having resigned his office as a Director of the Company in November, 1885, the Board then appointed Dr. Kingsbury, of Blackpool, to the seat so vacated. The Directors have not included in the accounts any charge for past services, and leave this matter to the general meeting of the shareholders. Mr. Broadbent's services as managing director have been secured again for the coming year. The capital and liabilities of the Company are shown to be as follows :—

2,850 shares £10 each, £6. 10s. called up (less £27. 10s. owing)	£18,525	0	0
Shares allotted as fully paid up to Mr. H. Smith, under his agreement	1,500	0	0
Sundry liabilities	852	4	4
Disposable balance	1,853	10	2

The following are the property and assets and preliminary expenses :—

Tram shed	£2,357	18	10
Engines, generators, motors, &c.	3,167	6	1
Centre channel and electrical fittings	8,354	14	3
Ten cars, &c.	1,784	3	3
Mr. M. H. Smith, being the consideration for the assignment of the Corporation concession and patent right for Blackpool	2,000	0	0
Engineer's commission	541	0	0
Miscellaneous capital expenses	556	5	1
Preliminary expenses	1,383	11	0
Stock	104	12	3
Debts owing to company	9	3	9
Cash in hand	2,444	10	0

On the revenue account the receipts are :—

Passenger receipts from cars	£4,960	17	3
Rents of advertising spaces on cars and tickets	165	0	0

The expenditure is detailed as follows :—

Horsing and driving cars	£115	9	11
Wages of drivers, conductors, checkers, ticket clerk, engineer, electrician, stoker, &c.	1,092	5	5
Electrical fittings, chains, collectors, &c., and repairs to electrical fittings, rewinding and repairing armatures, collectors, and other sundry repairs	301	2	5
Coke, coal, and oil	270	13	5
Ironmongery and smiths' work	75	4	11
Timber and joiners' work	28	12	0
Rent for year at 6½ per cent. per annum on cost of line (£11,137. 8s. 9d.) payable to Corporation of Blackpool under agreement	723	18	8
Rent of ground for tram shed, from December 31st, 1885, to 31st October, 1886, at £35 per year, and rent of office, North Shore	45	13	10
Income tax on profits, and rates and taxes on office, North Shore	42	13	1½
Gas and water	69	1	5
Advertising, printing, and stationery	45	6	8½
Salaries of managing director, secretary, manager, and auditor	221	10	0
Directors' expenses	65	11	3
Fire and employers' liability and insurance premiums	45	8	9
Law charges	12	8	7
Bank interest and commission	85	0	7
Miscellaneous expenses	94	13	7
Profit and loss for net revenue	1,791	2	8

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Nov. 24.		Business Done Week Ending Nov. 24. Highest.	Lowest.
Anglo-American	37½,	38½	38½	36
Do. Preferred	60½,	61½	61½	58
Do. Deferred	14½,	15⅛	15⅜	13¾
Brazilian Submarine	10⅞,	11⅛	11 1-16	10⅞
Cuba	11,	11½	11⅜	11¼
Do. Preference	18,	19	—	—
Direct Spanish	1¾,	2¼	2	1¾
Do. Preference	9½,	10½	9¾	—
Direct United States Cable	9⅜,	9⅝	9⅝	9
Eastern Telegraph	10⅜,	10⅝	10½	10 1-16
Do. 6 per Cent. Preference	14¼,	14¾	14½	—
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	11½,	11¾	11⅝	11⅜
German Union	9¼,	9¾	9¾	—
Globe Telegraph and Trust	5¾,	6	5 15-16	5¾
Do. Preference	12⅜,	12⅞	12⅞	12⅜
Great Northern	13¼,	13½	13⅜	13¼
Indo-European	33½,	34½	34½	—
Reuter's	7,	7½	7	—
Submarine	195,	205	200	—
West India and Panama	¾,	1	15-16	13-16
Do. 1st Preference	8¾,	9¼	9⅜	9¼
Western Brazilian	7,	7½	7½	7
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	⅝	⅝	—
Oriental	3-16	5-16	—	—
United Telephone	14,	14½	14½	14 1-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¾,	3¼	3½	3
Do. (fully paid)	4½,	5	4¾	4 11-16
Swan	1⅜,	1⅝	1½	1⅜
Maxim Weston	½,	⅝	—	—

MISCELLANEOUS.

Telegraph Construction	39	40	39½	39¼
India Rubber, Gutta Percha, and Telegraph Works	24½	25½	25¼	24¾

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NOTES.

SOUTHAMPTON TELEPHONE EXCHANGE.—This exchange now numbers 42 subscribers.

VIENNA.—The Vienna General Post Office is being fitted with about 350 incandescent lamps.

TRANSIT TABLES.—We have received from Messrs. Spon a copy of "Transit Tables for 1887," by Latimer Clark, F.R.A.S.

DIARIES.—Messrs. Griffith, Farran, and Co., send us a copy of the well-known "Blackwood's Shilling Scribbling Diary" for 1887.

CANAL LIGHTING.—The banks of the Canal de Donai are to be lit by electric light, in order to enable the navigation to proceed by night.

CHURCH LIGHTING.—The church at West Hanney, Berks, has been lit by electric light. The work was carried out by Mr. Stroud, of Wantage.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 26th November amounted to £4,396.

GLASGOW TRAMWAYS.—The Glasgow Tramway Company is seeking powers "to employ mechanical or electric in addition to animal power," for working its lines.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of November amounted to £50,817, and to £56,245 in the corresponding period of 1885.

SUBMARINE NAVIGATION.—A new submarine boat for naval warfare was tested last week at the West India Docks, with very satisfactory results. This boat is propelled and lighted by electricity.

CABLE INTERRUPTED.—The cable between Trinidad and Demerara is interrupted. Until repairs have been effected this will entail a delay of three or four days on telegrams for British Guiana.

FATALITY FROM LIGHTNING.—During a heavy storm at the Kimberley Diamond Fields, eight men at the bottom of a pit were struck by lightning; one was killed, and the others severely injured.

LECTURE ON THE ELECTRIC TRANSMISSION OF POWER.—On 25th November Mr. William Lant Carpenter, B.A., B.Sc., delivered a lecture on the Electric Transmission of Power, before the Bradford Philosophical Society.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of November amounted to £36,739, and to £40,427 in the corresponding period of 1885.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 26 were £3,637, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE "SPECIALISTS' SERIES."—We have received from Messrs. Whittaker and Co. a copy of the eighth volume of the "Specialists' Series," "On the Conversion of Heat into Work," a practical handbook on heat engines, by Mr. William Anderson, M.Inst.C.E.

PROJECTED PACIFIC CABLE.—A *Times* telegram reports the formation in New Zealand of the "Pacific Cable Company," which proposes to lay a cable from Brisbane *viâ* New Zealand, the Fiji and Sandwich Islands, to Vancouver, where it will connect with the Canadian system.

THE SOUTH KENSINGTON SCIENCE SCHOOLS.—We learn that Prof. Rücker, F.R.S., has been appointed by the Lord President of the Council to the Professorship of Physics in the Normal School of Science and Royal School of Mines, rendered vacant by the death of Prof. Guthrie, F.R.S.

"LIVES OF THE ELECTRICIANS."—We have received from Messrs. Whittaker and Co. a copy of the first volume of this series, to which we referred last week, containing biographies of Profs. Tyndall, Wheatstone, and Morse. We regret that pressure upon our space compels us to hold over a more detailed notice until next week.

THE EDINBURGH EXHIBITION AWARDS.—Messrs. Laing, Wharton, and Down ask us to mention that Mr. Miller, of Glasgow, is the agent for the Thomson-Houston system north of the Tweed, and that the gold medal obtained by the Thomson-Houston system at the Edinburgh Exhibition was awarded to Mr. Miller.

SALE OF MACHINERY.—On December 7th, 8th, and 9th, at the Alliance Engineering Works, West Drayton, near Uxbridge, Messrs. Wheatley Kirk, Price, and Goulty will sell by auction a quantity of machinery. The sale on the third day comprises a number of slotting, drilling, and planing machines and lathes of various kinds.

COLLIERY DISASTER.—We regret to learn that yesterday (Thursday) morning, at ten o'clock, a severe explosion occurred in a colliery at Ellmore, near Durham, which has been lit by electricity. It is feared that from ten to twenty lives have been lost. The dynamo house—apparently at the bottom of the shaft—was found to be in flames.

DIRECT SPANISH TELEGRAPH COMPANY.—Notice is given in the *London Gazette* of Tuesday that the petition presented to Her Majesty's High Court of Justice (Chancery Division), on the 26th ult., for confirming a reduction of the capital of the company from £190,000 to £95,000 is directed to be heard before Mr. Justice Kay on the 11th inst.

THE SOCIETY OF TELEGRAPH-ENGINEERS.—The annual general meeting of the Society of Telegraph-Engineers and Electricians will be held at the Institution of Civil Engineers at 8 p.m. on Thursday, December 9th, when the president, vice-president, members of the council, and other officers of the society will be elected for the year 1887.

MEXICO.—We learn that an exhibition of electrical appliances is being held this month in the City of Mexico. The streets of Mexico have been supplied with electric light for over two years. The plant is now to be extended by the addition of 40 arcs. The town of San Luis, Potosi, has ordered the erection of the same number of arcs for street lighting.

PENZANCE.—The *Royal Cornwall Gazette* states that the public subscription which is being raised in Penzance in order to light the streets of the town by electricity has resulted very favourably so far, and in all probability the matter will shortly be proceeded with. The Gas Company have, as usual under similar circumstances, been aroused to action, and are putting in a number of extra powerful burners in several parts of the town.

TELEPHONY IN GERMANY.—The *Centralblatt für Electrotechnik* announces that the trunk line between Munich and Augsbourg has been completed, and the results are very satisfactory.—The town of Wurzbourg is to be provided with a telephone exchange.—Upon the German State lines Siemens transmitters have been exclusively employed hitherto; these are now to be given up in favour of a transmitter of the simple microphone type.

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SPANISH TELEGRAPHS.—From the latest report of the Spanish Minister of Posts and Telegraphs, we learn that during the six months to which the report refers, 30 new telegraph offices were opened in the country, involving the addition of 167 kilometres of wire. There are at present open 533 State offices and 359 belonging to the railways. The total number of despatches transmitted during the half year was 1,332,394, including 342,202 foreign.

SPANISH TENDERS.—In addition to the tenders for the supply of telegraph posts in several provinces of Spain, to which we lately referred, it is announced that tenders will also be received on the 26th instant for the supply of 5,500 posts for Segoria and Avila, viz., 2,500 of a length of six metres, at a maximum price of eight pesatas each; 2,500 of seven metres, at a maximum of nine pesatas; and 500 of eight metres, at a maximum of 10 pesatas each.

SOCIETY OF ARTS.—We would remind our readers of the paper on "Glow Lamps, their Use and Manufacture," to be read before the Society of Arts on the 8th inst. by Major-General C. E. Webber. At the meeting after Christmas the following papers (among others) will be read:—"On the Development of the Mercurial Air Pump," by Prof Silvanus P. Thompson; "On Progress in Telegraphy," by Mr. W. H. Preece; and "On Electric Locomotion," by Mr. A. Reckenzaun.

TELEGRAPHS IN THE ARGENTINE REPUBLIC.—From a report recently issued we take the following figures relating to last year's working of the telegraph system in the Argentine Republic:—The total number of messages transmitted was 658,000, showing an increase of 15 per cent. over the preceding twelve months. The receipts amounted to $271,000, and the expenditure to $515,000, leaving a deficiency of $244,000. During the last five years 4,190 miles of wire have been erected, the total mileage being now over 7,400.

LECTURE ON ARTIFICIAL LIGHTING.—A lecture on "Artificial Lighting" was delivered last week by Mr. John Slater, B.A., before the advanced class of construction at the Architectural Association. Mr. Slater strongly endorsed the advantages of electric lighting, and gave some figures with regard to the cost of an installation of 50 lamps. In the report now before us he is made to say that "23,360 hours' light" can be obtained "at an average cost of 2½ farthings per hour." We do not profess to understand this, but no doubt the reporter is alone to blame.

MADRID.—In connection with the scheme for a central lighting station at Madrid, which has been taken in hand by the "Mercantile Club" of that city, two representatives of the club have been deputed to visit the principal cities of Europe in which electric lighting on any large scale has been adopted with a view to the selection of a system. The deputation had arrived last week in Milan. Unhappily, we fear that there will be little inducement for them to visit this country. On their return they will issue a report which will possibly prove interesting.

THE "MONARCH" CABLE SHIP.—During one of the recent storms a vessel was wrecked upon the north coast of the Isle of Man, close to the point where the three wire cable comes on shore. The cable received some damage, though not sufficient to stop working. The repairs were effected by the "Monarch" on the 24th ult. She left Holyhead at 3 a.m., made the passage to the island through a thick fog, picked up the cable, located the fault, cut it out, and had all made good by 3 p.m. the same day. Mr. Lumsden, chief electrician, assisted by Messrs. Cully and Pollard, were in charge of the operations.

THE LIGHTING OF RAILWAY CARRIAGES.—The *Pall Mall Gazette* has recently published several letters containing bitter and certainly well-founded complaints as to the lighting of the carriages employed in the suburban traffic of many of the leading companies. The Brighton and South Coast line seem at length to have satisfied themselves as to the practicability and efficiency of the system of electric lighting which they have for some time employed upon a small scale, and, as we recently mentioned, are about to extend its use. If the public will only take the trouble to keep up the agitation there is little doubt that other lines will eventually follow their example.

THE ELECTRIC LIGHT AT VIENNA.—A rather curious state of affairs exists at Vienna with regard to the long-projected central electric lighting station in that city. Some time ago the municipal authorities placed their veto upon the scheme as it then stood. Now, however, according to *La Lumière Electrique*, the Minister of the Interior has granted authorisation to the same parties to whom it had been refused by the municipality. We do not know whether the Ministerial decision absolutely overrides that of the municipal authorities, but the upshot seems to be that negotiations have been reopened between the latter and the authors of the scheme.

THE GAULARD-GIBBS SYSTEM.—The National Company for the Distribution of Electricity by Secondary Generators informs us that they have received information by cable of the successful opening of an installation of 4,000 lamps under the Gaulard-Gibbs system at Buffalo by the Westinghouse Electric Company. This work has been carried out in a remarkably short time. It appears that two months ago, when one of the principals of the Westinghouse Electric Company (now in England) left the States, even the negotiations for this installation had not yet been commenced. We should like to know whether the distribution is effected in parallel or in series connection in this case.

A QUERY RE TRANSFORMERS.—*Apropos* of the forthcoming action Gaulard-Gibbs *v.* Ferranti, one of our French contemporaries not unnaturally asks how it is that the only extensive installation of transformers which has been carried out on the Gaulard-Gibbs system in this country should have resulted in acknowledged failure, while in France, and notably at Tours, the Gaulard Gibbs transformers have given perfect satisfaction. We are under the impression that the answer will be found in the fact that the economical advantages attending the use of transformers has at Tours been largely sacrificed to the simplicity of regulation which is afforded by the use of a parallel system of connection. In this country economy must always be the first consideration.

LIGHTNING.—Since it has become possible to study the path of a lightning flash by means of electricity, several interesting observations have been made which we have from time to time recorded. It has recently been established by Herr Leyst, of the Pawlowsk Observatory, that a flash not unfrequently divides into two or more branches. In one case a flash divided into two branches, forming an angle of about 75°; then, after traversing a certain space, the branches turned towards each other, and presently reunited, thus forming a quadrilateral figure. In another interesting flash the same identical path was lit up four times in succession at short intervals. The thunder which followed lasted 80 seconds.

LIGHTING OF A FERRY STEAMER.—Messrs. J. D. F. Andrews and Co., of Glasgow, have just completed an installation on board the Tay ferries steamer at Dundee. The boat is luxuriously fitted up throughout, and the electric light fittings are in accordance with their surroundings. The dynamo is

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one of Andrews' slow-speed, self-regulating type, running at 590 revolutions, and driven by belting from a Tangye engine. A 10-ampere arc lamp, of 1,000 candle-power, is carried on a flag pole at a height of 30ft. above the deck, and is used at the landings for lighting the gangways. We understand that during the last two years Messrs. Andrews have fitted a total of very nearly 10,000 lamps on steamers of various kinds.

Welding by Electricity.—On this subject we have received a letter from Mr. Radcliffe Ward, who wishes to call attention to the fact that in the year 1884 Captain W. Blanch Brain, who was at one time associated with Mr. Ward in connection with the British Electric Light Company (now defunct), was at work upon experiments connected with welding by electricity. Mr. Ward thinks it probable that Captain Brain has therefore a claim to priority in this matter over both Prof. Elihu Thomson and Mr. Duncan. Mr. Ward also states that Captain Brain had succeeded in obtaining a return of 80 per cent. in the electric transmission of energy "at a time when men more purely scientific held that 50 per cent. was the possible maximum."

Effluviography.—This euphonious name has nothing to do with the science of ill-odours, but has been applied by M. D. Tomassi to the effects produced by the silent discharge upon a sensitised gelatine-bromide plate. After an exposure of some minutes' duration an image may be obtained from an electrified body, although (if we understand the author aright) the potential may not be high enough to give any sign of light, and when all other light is excluded. The image may be developed in the usual manner. M. Tomassi considers that the silent discharge produces the same effect as the ultra-violet rays, and may form a connecting link between the two extremes of the spectrum, consisting of what may be called "electric rays." But we doubt whether this suggestion will obtain any wide acceptance.

Telegraph Clerks and the Royal Commission.—An enthusiastic meeting of the Post Office telegraphists was held in Liverpool on Saturday evening, when great satisfaction was expressed at the appointment of a Royal Commission to inquire into the working of the Civil Service. Discontent and agitation had, it was stated, been rife in the telegraph service ever since its transfer to the State, and the staff were determined that, so far as their department was concerned, no effort on their part should be spared to enable the inquiry of the Commission to be searching and thorough. Resolutions were unanimously passed condemning in strong terms the present system of promotion by selection, as giving opportunities for favouritism and injustice, and an earnest hope was expressed that the commission would not only recommend a more equitable system, but make close inquiry into the fairness of past promotions, and into the mode of exercising those absolute powers in this and other directions which the surveyors practically, though not nominally, possess. A committee was appointed to prepare and lay before the surveyor of the district a statement of information wanted.

The Early Progress of Telegraphy.—In the year 1844, seven years after the practicability of the electric telegraph had received complete demonstration, it was still possible for a paragraph such as the following to appear in *The Times* (April 14th, 1844):—"The first intelligence of the arrival of H.R.H. Prince Albert in this country from Germany, on Thursday last, was communicated to Her Majesty at Windsor Castle by Galvanic telegraph on the line of the Great Western Railway. Within one minute of the arrival of H.R.H. at the Paddington terminus the information had reached Slough, at which station a special messenger, mounted upon one of the fleetest horses in the royal stables, was stationed, by command of the Queen, who proceeded with the gratifying intelligence to the castle, where he arrived in eight minutes and a half from the time of leaving Slough. Thus the news of the Prince Consort's return to England reached Her Majesty, and their Majesties, the King and Queen of the Belgians, in less than 10 minutes after his royal highness had arrived at Paddington, and 40 minutes before the prince had reached the royal residence at Windsor."

Long Distance Telephony.—In the year 1884 the American Bell Telephone Company determined to undertake a series of elaborate trials and experiments in long-distance telephony. For this purpose a special test line, 300 miles in length, was erected between Boston and New York, and for more than twelve months experiments were carried out under all conceivable conditions, and with every known form of instrument. The line itself was of hard drawn copper, and the experiments were chiefly directed to the determination of the best means of avoiding inductive disturbance, and to the discovery of the most suitable transmitter. With regard to the latter point, it is certain that the chief object to be aimed at is the use of comparatively large currents while retaining the necessary delicacy of action. From a circular recently issued by the company we understand that they have succeeded in developing a satisfactory transmitter, which is ascribed to the conjoined labours of Blake, Edison, Berliner, Gilliland, Hughes, Hunnings, and others, but of which the precise construction does not appear. As for the elimination of induction, the company has arrived at the conclusion that the necessary and sufficient condition is the use of a metallic circuit. With these arrangements conversation over the three hundred miles from Boston to New York is now thoroughly practicable and satisfactory. In order to be able to avail themselves of this extension, we understand the local telephone exchanges in New York, Brooklyn, and the adjacent towns are now taking steps to provide their subscribers with metallic circuits.

Extraordinary Medical Experiments.—A Paris correspondent of one of the daily journals says:—"The chief French surgeons and medical professors have for some time been carefully studying the effects of mesmerism on the female patients of the Salpêtrière Hospital, and M. Babinski, a clinical surgeon of that establishment, has just effected a series of experiments, the results of which would seem to open up a new future for medical science. M. Babinski tried to prove that certain hysterical symptoms could be transferred by the aid of the magnet from one patient to another. He took two subjects, one a dumb woman, afflicted with hysteria; and the other a female who was in a state of hypnotic trance. A screen was placed between the two, and the hysterical woman was then put under the influence of a strong magnet. After a few moments she was rendered dumb, while speech was suddenly restored to the other. M. Babinski also effected temporary cures of paralysis in the same manner." We would suggest to M. Babinski that he should repeat his experiments with pieces of wood or copper of the same size, shape, and colour as his magnets, when we have not the least doubt that precisely the same measure of success would be attained. It is a great pity that the exploded fallacy of "curative magnetism," which so readily lends itself to the purposes of the charlatan and the quack, should receive the least countenance from any one claiming to be an authority in medicine. The employment of *electricity* in therapeutics stands upon a totally different basis, although its true function and limitations still

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remain to be worked out, and afford a most legitimate field for inquiry.

Pictures Produced by Lightning Flashes.—The American Institute has recently had a lively discussion over the photograph of a young lady which was alleged to have been due to the direct action of a flash of lightning. As we mentioned some weeks ago, the picture in question appeared upon the surface of a brass plate which the young lady was holding in her hand at the time of a severe thunderstorm. During the discussion at the American Institute, Mr. T. C. Martin read the following paragraph, which appeared in *The Operator* for January 1, 1876:—"We learn that within the last two weeks a singular discovery has been made at the house of Jesse Garth, for many years deceased. It is said that a distinct and accurate likeness of Mrs. Garth, who has been dead for twenty years, can be seen on a pane of glass in the upper sash of one of the windows, presenting very much the appearance of a photograph negative. The discovery is said to have been made by a woman who was washing clothes in the yard, who imagined some one was watching her through the window, and went inside to see who it was. We gather these facts from Dr. Charles Brown, who has himself seen the singular picture. Dr. Brown remembers that about twenty years ago Mr. Garth told him that his wife, while standing at the window, was stunned by a sudden flash of lighting, and the doctor's theory is that the outline of her features was photographed on the window at the time. The youngest daughter of Mr. Garth, and others who were acquainted with Mrs. Garth, have seen the picture and pronounced it a striking likeness."

The Management of Accumulators.—We have received a copy of a pamphlet of twenty pages, entitled "The Management of Accumulators," by Sir David Salomons. The author expresses a hope that the subject will be found "to have been made clear to the understanding of the majority of those whose daily routine deals with electric lighting accompanied by an accumulator." Sir David's wide practical experience upon this subject is well known, and we would cordially recommend this little work to those for whose benefit it is primarily intended, feeling sure that as regards all practical details of the management of the cells—and many such details have to be attended to if the installation is to be worked with success and economy—the author's anticipations will be fully realised. Upon certain of the more theoretical points Sir David has arrived at conclusions rather different from those which are usually entertained, but this feature will detract little, if at all, from the value of his practical observations. The description of the accumulator room at Broomhill, which has been specially built for the purpose, and is equipped with every possible appliance for facilitating the manipulation of the batteries, will be of interest to all; but, unfortunately, we fear that the number of consumers who could be induced to fit up a battery room "regardless of expense" is but very limited—the first convenient cellar is the usual destination of accumulator cells. One very simple "dodge" of Sir David's we may mention for the benefit of our readers. To avoid the nuisance of the acid fumes, and the very perceptible weakening of the solution caused thereby, it is found perfectly effective to place slips of glass at an inclination over the cells; the spray then collects in drops and falls back into the liquid.

The Electric Light at San Francisco.—A correspondent of the French journal, *l'Electricité*, gives an interesting account of the development of the arc light at San Francisco. The work is entirely in the hands of the California Electric Light Company, who hold a license for the Brush system. The central station at San Fransisco was one of the very first to be established, dating back to the year 1879, when the company commenced operations with a single Brush machine and six 2,000 candle-power lamps. The hours of lighting were from dusk to midnight, and a rental of $10 per lamp per week was charged. In January, 1880, the number of machines had increased to four, furnishing current to 64 arcs, while the price was reduced to $7 per week. In the month of April the station was destroyed by fire; but in less than four weeks the plant was again in working order. Since that period the number of arcs has steadily increased, and now exceeds 400. The original machines have been replaced by the new Brush pattern with improved armatures, each furnishing 60 to 65 arcs of 2,000 candles. Four steam engines are employed, supplied with steam by five tubular boilers. (Further particulars as to motive power are not given.) The conductors are of 4 mm. diameter, covered (only) with platted and varnished cotton. The lines are carried upon posts through the streets. There are several circuits of which the longest is over 12½ miles in extent. The rental has been reduced to $5 per lamp per week for lamps burning till midnight only, and $7 for those burning all night. The cost of installation, maintenance, and carbons is undertaken by the company. San Francisco also possesses a large number of isolated installations of incandescent lamps carried out chiefly by the Edison Company.

The Electrolysis of Ammonic Sulphate.—At the meeting of the Chemical Society, on the 18th inst., a preliminary note on "The Electrolysis of Ammonic Sulphate" was read by Mr. Herbert M'Leod, F.R.S., as follows:—"When a neutral solution of ammonic sulphate is electrolysed in a U-tube provided with platinum plates as electrodes, nearly pure oxygen is evolved at the positive pole and hydrogen at the negative. For one volume of gas from the positive pole a quantity varying between 4·7 and 5·4 volumes is evolved from the negative pole. A small amount of ozone is produced. On mixing together the electrolysed liquid at the poles a strongly alkaline liquid is obtained, containing a considerable quantity of "active" oxygen. When the liquid is first neutralised with sulphuric acid, then treated with excess of baric chloride, and the baric sulphate filtered off, the liquid deposits baric sulphate on boiling, an indication of the presence of persulphuric acid in the solution. When sulphuric acid that has been electrolysed is exactly neutralised with baric hydrate, the precipitate filtered off and the liquid boiled, baric sulphate is precipitated; at the same time the liquid becomes acid and a further quantity of baric sulphate is thrown down on the addition of baric chloride." In reply to a question by the President, Prof. McLeod said that Faraday in the experiments which gave results differing from those now described, had used an alkaline solution of ammonium sulphate in ammonia. Dr. Messel asked if the deficiency in oxygen might not be due to the formation of hydrogen peroxide. In experiments on the electrolysis of sulphuric acid solution (with a current of 60 amperes), he had at all events observed the characteristic colour on application of the chromic acid and ether test. Prof. McLeod said that he had always failed to detect hydrogen peroxide.

Proposal for Lighting Trains in Tunnels.—During the last few years several of the French railways have employed a very simple method, which seems to have been first introduced by M. D. Baillebache, for automatically signalling the passage of a train. This method consists in separately insulating one or more of the rails, and connecting them by an insulated wire with a bell at the signal station. When the train runs over this part of the line, the circuit is

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completed through the wheels to earth. M. de Baillebache now proposes to employ a modification of this arrangement in order to automatically light the train while passing through tunnels. Instead of insulating the rail itself, he lays an insulated copper strip along one side of the rail in such a position that the flanges of the wheels make good contact with the copper. The circuit is then completed to earth as before. These are all the details which have as yet appeared; we suppose, however, that M. de Baillebache has not overlooked the fact that in such an arrangement it would be necessary also to insulate the tyre of the wheel from the axle and the body of the carriage. As a more practicable modification, we would suggest the use of a trailing collector placed in the guard's van, and arranged to be lowered upon the insulated strip when required. Secondary batteries would, of course, be employed, and as there would be little or no difficulty or expense in removing them to a convenient station for re-charging, the system would certainly seem to be worth attention. Upon some lines where tunnels are long or numerous, as for instance on the Great Western Railway between Corsham and Bristol, the arrangements for temporarily lighting the trains are a source of considerable trouble and expense, as well as loss of time, and it might easily be found on investigation that some such method as that proposed would prove a decided gain in economy as well as efficiency. Since writing the above we have learnt that a very similar scheme was proposed some years ago by Mr. Crompton for lighting the Metropolitan and District lines.

The Telephone at Preston.—The town of Preston has for several years occupied a peculiar position in matters telephonic. In the year 1881 an exchange was opened by Mr. G. Sharples, a local electrician, which met with a very considerable success. A little later the Lancashire and Cheshire Telephone Company came into the field, and started a rival exchange. The result was that the Preston public (as some compensation for the inconvenience of having two separate and distinct telephone systems) got their connections made at a remarkably low figure. Indeed, for some considerable period the rival exchanges were willing in some cases to accept customers absolutely "free gratis for nothing." The rates were afterwards raised from £6 to £8 per annum, which still allowed the Preston people to boast of having the cheapest telephone system in the country. At length, however, the inevitable amalgamation has been effected, Mr. Sharples' exchange has been purchased by the Lancashire and Cheshire Company, and the rates will be raised to £10 all round. The subscribers will, however, scarcely have any reason to grumble at the change; the inconvenience of the two separate systems had grown to a serious evil, and in addition to the advantage of getting rid of this source of annoyance, the subscribers to the local exchange will now be enabled to avail themselves of the system of trunk lines by which all the chief towns in Lancashire and Cheshire are connected. As some further consolation for the increase of tariff we understand that the company proposes to allow communication between Preston and the principal sea-side resorts on the Lancashire coast free of extra charge. This has reference to the towns of Blackpool, Lytham, St. Annes, and Fleetwood. The total number of subscribers now approaches 500. The instruments employed in the local exchange were those of the original Bell Company, of which Mr. Sharples had, with admirable foresight, purchased a large number in the early days when telephones could be bought and sold outright. With equal discrimination in disposing of his exchange to the Lancashire Company, Mr. Sharples has retained the whole of these instruments in his own hands, and these he will shortly place upon the market.

Unsuspected Dangers with Frictional Electricity in Blasting.—In the New York *Electrical World* Mr. W. E. Irish writes as follows:—"Some years ago, when I was engaged in assisting to carry out a series of experiments in the firing of torpedoes and mines by means of electricity, an incident occurred which nearly resulted in a most serious calamity. About a week after the commencement of a long series of experiments several charges of gunpowder, gun-cotton, and dynamite were submerged in a river about 100ft. apart, the object being to learn what the effect of each would be when fired under the same conditions. The firing station and position of the charges in the river were on this occasion totally obscured from each other and about one mile apart. The cable employed consisted of a stranded copper conductor well insulated with 'Hooper's compound.' Two lines were used for firing the charges, and a third cable was laid for communicating between the two points by telegraph. The three cables were laid on the grassy land parallel to, but separated from, each other by a space of a few inches throughout the greater part of their length. Electricity for firing the charges was obtained from Baron Von Ebner's ebonite-disc frictional machine, which is too well known to need description. The two ends of the cables at the river were each connected to a charge, while at the firing station one end was carefully sealed and suspended in the centre of the firing room as a precaution and guard against the possibility of its coming in contact with the firing battery or machine. The other end was connected to the electric generator in connection with the charge to be fired first. Final arrangements having been completed and all made ready, instructions were telegraphed to fire No. 1, charge, which was carefully and correctly done. Scarcely, however, had the firing key been depressed when word was wired from the river 'to stop further operations, and leave everything at the firing station in the exact position it then occupied, as two charges had been fired instead of one only, as directed; and that in consequence a boat and party of men engaged near the charge which ought not to have been fired had most miraculously escaped being blown to pieces.' This was declared by the operators at the firing station to be impossible through any action or neglect on their part. The matter, however, was too serious to be left without a thorough and searching investigation. A very careful examination and insulation test of the end of this cable in the firing station proved that it had not been injured or tampered with in any way. It was determined to unravel the mystery, if possible, and we were not long in discovering that under precisely the same conditions the same result was always obtained. It was satisfactorily proved that detonation was not the cause, and eventually it was discovered that the firing of the second charge was due to induction. To remove all doubt two half miles of the same description of cable were placed one foot apart throughout their entire length, fuses been connected to the cables at one end to represent the charges, and the wire being then grounded as before. To one of the cables at the firing station the frictional machine was connected, while the other end was carefully sealed and suspended in the same room as before and at least ten feet away from the electric generator. The discs of the machine were given twenty revolutions and the condenser was discharged, when both fuses fired. Further tests led to the conclusion that it would be dangerous on cables running parallel and within 40 or 50ft. of each other, to employ the frictional machine where more than one charge is connected. The frictional machine was now removed, and tests were made with dynamic machines and voltaic batteries, but in no case did we succeed in firing more than the one charge, even when the wires were close together."

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 52.)

In constructing a dipping needle the steel bar is accurately balanced about its centre of gravity before it is magnetised. After magnetisation it will then take up the line of magnetic dip. As it is not easy to support a needle so that it is free to turn in every direction about its centre of gravity, dipping needles are generally balanced on a knife edge, like the beam of a balance, so that they are free to turn in a vertical plane, and this plane is made to coincide with the magnetic meridian by turning the instrument by hand. If such a dipping needle be placed with its plane of motion perpendicular to the magnetic meridian the needle will assume a vertical position, for the horizontal component of the earth's force will now have no tendency to turn the needle, and the vertical component will be left to act alone.

When a needle is magnetised it is impossible to secure the exact coincidence of the geometrical axis and magnetic axis of the needle. In determining the magnetic dip the inclination of the geometrical axis is read by the graduated scale, but the magnetic axis may be inclined at a greater or less angle than the geometrical axis. By raising the needle from its bearings and replacing it inverted the magnetic axis will be retained in the same direction, but the geometrical axis will in the second case be as much above (or below) the magnetic axis as it was formerly below (or above) it. The mean of the two readings of the geometrical axis will be the true reading for the magnetic axis.

But the magnetic axis itself may be deviated from the direction of the earth's force on account of the axis of rotation not passing through the centre of gravity of the needle. The usual mode of correcting this error is to demagnetise the needle and magnetise it in the opposite direction *to the same strength as before.* The ends of the needle being now reversed, if another pair of readings be taken and the mean of these determined, the mean of the two means will be the true direction of the dip. Care must be taken that the strength of the needle when remagnetised is the same as before, and this can be determined by counting the number of vibrations it can execute in a minute under the earth's action.

The difficulty arising from the want of coincidence between the geometrical and magnetic axis of the needle arises also with the ordinary compass needle, or declination magnet. It can be entirely obviated by inverting the needle upon its pivot, or suspension fibre, for the magnetic axis will remain in the same direction whichever face of the needle is uppermost, while the geometrical axis will make equal angles on opposite sides of the magnetic axis in the two positions of the needle, so that the mean of the readings of the geometrical axis, or of any other line drawn upon the needle, will be the true reading for the magnetic axis.

In magnetic observatories it is usual to register continuously the declination, the horizontal intensity, and the vertical intensity. From the two latter the total intensity and the dip can be determined as above explained.

The method of registration consists in causing a beam of light to be reflected from a small mirror attached to the magnet whose motion is to be recorded, and converged upon a piece of sensitised paper which completely surrounds a cylinder. The cylinder makes one rotation in 24 hours, being driven by a train of clock-work. If the magnet remains stationary, the spot of light will describe a straight line on the paper, but if the position of the magnet vary its motion will be recorded by irregularities in the line.

The declination is registered by means of a magnet suspended by a single fibre. This declination magnet always sets in the magnetic meridian, changing its direction as that of the meridian changes, since there is no sensible torsion to counteract the influence of the earth's force.

The horizontal intensity is registered by a *bifilar magnetometer.* This is a bar magnet suspended from a torsion head by two threads. The torsion head is turned so that the magnet is compelled, under the action of the suspension threads, to set with its magnetic axis at right angles to the magnetic meridian. The couple exerted by the threads when the needle points east and west is then experimentally determined, as well as the change produced in the value of this couple when the needle turns through one degree in either direction. The magnitude of the couple will depend on the weight of the magnet and its appendages, the distances between the threads at the top and bottom, and their length. If the horizontal intensity increases the north end of the needle will be pulled towards the north, notwithstanding the opposition of the bifilar suspension, until the increased angle between the threads of the bifilar causes their tension to balance the increased couple exerted by the earth. If the horizontal intensity diminishes, the bifilar suspension will cause the magnet to turn through a corresponding angle, in opposition to the earth's action.

The vertical intensity is registered by the *balance magnetometer.* This consists of a bar magnet capable of turning in the plane of the magnetic meridian, and so supported that it rests with its magnetic axis nearly horizontal. To effect this there is a small weight capable of sliding along the bar, and this is pushed, in north latitudes, towards the south pole of the magnet, until the moment of its weight balances the couple due to the vertical component of the earth's magnetic force. If the vertical intensity increase, the north pole of the magnet will dip through an angle nearly proportional to the increase, like the beam of a balance when there is a slight excess in one scale pan; if the vertical intensity diminish, the magnet will dip towards the south. The cylinder which carries the sensitised paper for the balance magnetometer turns about a vertical axis, and the spot of light moving up and down as the vertical intensity varies, a curve recording these variations is delineated.

When magnetic measurements are made in localities where there is no fixed observatory, the unifilar magnetometer is employed, together with a dip circle. By these instruments the declination, the horizontal intensity, and the dip are observed, and hence the vertical intensity and the total intensity can be immediately determined. The horizontal intensity is determined by the unifilar magnetometer from the number of swings executed in a minute by a magnet suspended in a wooden box by means of a silk fibre. From the moment of inertia, and the number of swings executed in a minute, the horizontal couple acting on the magnet can be inferred. This couple is equal to the product of the magnetic moment M of the magnet, and the horizontal intensity H of the earth's magnetism. In order to determine the value of the quotient of the magnetic moment M, divided by the horizontal intensity H, the magnet is placed at a certain distance from a compass needle, which is suspended by a single silk fibre, and the deflection produced in the needle is measured, the magnet being moved as the needle turns, so that the axis of the magnet may always be in the line drawn through the centre of the needle at right angles to the axis of the needle. The magnet is then said to be "end on" to the needle. Having determined the product M H and quotient $M \div H$, the values of M and H can at once be found.

The horizontal intensity is greatest at the magnetic equator; the total intensity is greatest near the poles.

Œrsted, in 1819, showed that when a wire conveying a current is brought near to a freely suspended magnetic needle, forces are introduced tending to make the needle set at right angles to the wire. The experiment was the starting point of the galvanometer and of the electric telegraph.

Faraday shortly afterwards showed that the action discerned by Œrsted was due to a force in virtue of which each pole of the magnet tended to revolve continuously around the wire conveying the current—the north pole in one direction, the south pole in the opposite direction. As the poles are held together by the material of the magnet, it is clear that in Œrsted's experiment this continuous rotation cannot take place, but each pole tending to go as far as possible in its own direction, the magnet will at length become at right angles to the wire. The needle will then be exposed to tension and to a bending moment; but there will be no further tendency to cause it to turn about its point of support. If the magnet could be rendered perfectly flexible the north pole would go round the conductor in one direction, and the south pole in the other, until the magnet had completely wound itself up in a tight coil around

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the conductor. The character of the force around the conductor may be exhibited in iron filings just as in the case of magnets. If a small hole be made in a card and a wire conveying a current be made to pass through the hole at right angles to the card, and if iron filings be scattered on the card and slightly shaken, the filings will arrange themselves in concentric circles around the wire. Thus the lines of magnetic force around a straight wire which conveys a current are concentric circles round the wire. The direction of the magnetic force is given by the following rule :—

A current flowing in a conductor will tend to make the north pole of a magnet move round the conductor in the direction in which a right-handed screw would rotate if advancing with the current, and screwing its way through a solid.

The south pole of a magnet will, of course, tend to revolve in the opposite direction, and since the force on the south pole of a magnet is always opposite to that on the north pole, it follows that the magnet will turn until its axis is perpendicular to the wire, unless some other force or forces prevent it.

If the wire be twisted into a coil, lines of force will pass round every element of the wire in the direction indicated above, and these passing all in the same direction through the coil it follows that—

If a current flow round a coil a north magnetic pole will tend to pass through the coil in the direction in which a right-handed screw would advance if rotating in the direction of the current.

Since the south pole of the magnet would tend to move in the opposite direction, it follows that a magnet suspended within a coil of wire will tend to turn so that its magnetic axis is perpendicular to the plane of the coil. This arrangement constitutes a galvanometer.

An astatic system is a mechanical system which has no definite position of equilibrium, but which will rest in any position in which it is placed, though free to move.

Two magnetic needles of equal magnetic moment rigidly connected so that their axes are parallel but their north poles point in opposite directions, constitute a system which is astatic as far as the earth's magnetic force is concerned, for whatever couple may be exerted by the earth upon one needle an equal and opposite couple is exerted upon the other. Such a pair of needles suspended so as to be free to turn in any direction would behave as though there were no magnetic force exerted by the earth.

Practically it is impossible to obtain two needles whose magnetic moments are *exactly* equal, and to connect them so that their axes are *exactly* parallel. If the axes were parallel but the moments unequal, the needles would set in the magnetic meridian, in obedience to that of greatest magnetic moment. If the magnetic moments were equal, but the axes not parallel, the needles would set so that the vertical plane bisecting the acute angle between the axes would be perpendicular to the magnetic meridian. When, as is the case in practice, the moments are not quite equal and the axes not quite parallel, the system takes up a position intermediate between those just mentioned. It is therefore not strictly astatic, but the couple exerted upon it by the earth's magnetism when the needles are deflected from their positions of rest is extremely small.

If two magnetic needles are suspended one above the other so as to form an astatic combination, and the lower needle is surrounded by a coil of wire through which a current can be sent, a very delicate "astatic" galvanometer may be formed. It will be seen that the current flowing through the upper portion of the coil will tend to turn both the needles in the same direction since their magnetic axes are parallel but reversed.

Sometimes a coil of wire surrounds each needle in an astatic galvanometer, and the current is then made to flow round the two coils in opposite directions.

When a current flows round the coil of a galvanometer, the needle of which is in equilibrium when parallel to the plane of the coil if no current is passing, the needle will be deflected through an angle which increases with the strength of the current. The needle will rest when the couple exerted upon it by the earth is equal and opposite to that exerted by the current. If the length of the needle be very small in comparison with the diameter of the innermost circle of wire in the coil the *tangent* of the angle of deflection will be proportional to the current, and inversely proportional to the horizontal intensity of the permanent magnetic field in which the needle swings. Hence, the sensibility of the instrument will be increased by diminishing the intensity of the permanent magnetic field. This is usually effected by means of a permanent controlling magnet which is turned so as to oppose the earth's action on the needle, and by causing this magnet to approach or recede from the needle the earth's action can be wholly or partially neutralised, and by properly turning the controlling magnet the galvanometer may be employed with its coils in other planes than the magnetic meridian. The manner in which the directive action of the earth has been overcome in the astatic galvanometer, so as to increase the sensibility of the instrument, has been already explained.

(To be continued.)

TESTING DYNAMO MACHINES.

BY JAS. SWINBURNE.

(Concluded from page 33.)

In some cases there may be a little difficulty in arranging cells to give very large currents. The two machines may then be run off as shown in Fig. 3. The pulleys are arranged so that the generator runs at its normal speed, and the motor runs slow enough for its *e* to be the same as the *e* of the generator. The loss in the system is not made up by supplementing the electromotive force of the generator, as in the last case, but by increasing the current in the armature of the motor. A small dynamo, D, giving, say, 110 volts, is arranged to excite the field-magnets of both the large machines, and to work into the motor armature in parallel with the generator.

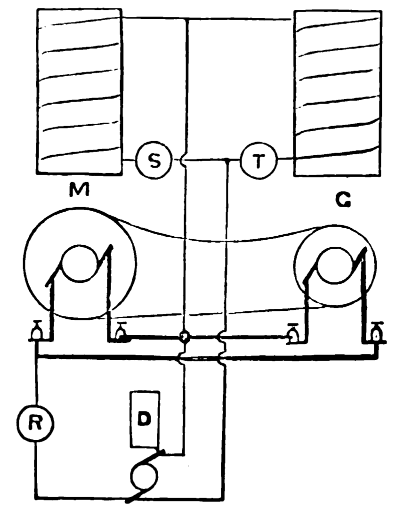

Fig. 3.

The current from D is regulated by the resistance till G is under normal conditions. The field and armature losses are taken in the usual way, and the stray power determined. To assess the stray power the belt slip may be first roughly deducted, and the remainder divided according to the power taken by each machine when run as a motor with no load, and with the same armature electromotive force as when under test. The real loss from belt slip can then be more accurately found, and the calculations made again. Instead of using pulleys of different diameter the field of M may be weakened, as in Dr. Hopkinson's method.

It is hardly necessary to go into the question of coupling up compound machines for the same tests, as the stray power is estimated in the same way, the only difference being some slight complications in the connections. The whole difficulty lies in the accurate determination of the stray power and in the accurate division of it into loss in the motor armature, loss by belt slip, and loss in the generator armature.

Fig. 4 shows two machines coupled to secondary batteries; the motor may be any machine of sufficient power to drive

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the generator. This is the method used by Mr. Butler for testing motors, and it is virtually the same as Capt. Cardew's arrangement. To find the loss of power, the watts spent in M and those given back by G are taken, and the difference less the power spent on resistance gives the stray power. Each machine is then moted separately with no load, as already explained, and the stray power in each determined. This method and Captain Cardew's have the advantage that any machine that is large enough will do as a motor; but they have the disadvantage of needing three large machines or else two large machines and a lot of secondary cells. Captain Cardew's method also demands a resistance frame large enough to take the whole output of the generator.

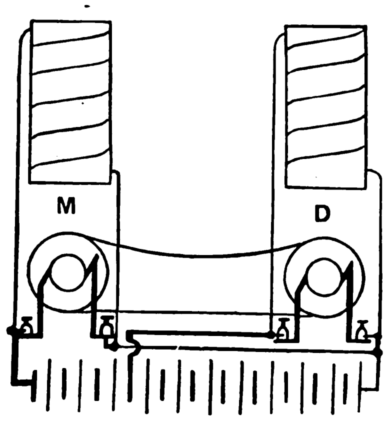

Fig. 4.

On the 7th of August last two machines, made by Messrs. Crompton and Co., for the War Department, were tested by Captain Cardew, according to his own method; the writer was fortunate enough to be there and witnessed the tests.

The particulars of the machines are as follows:—Armature resistance ·027 hot, field-magnet resistance 7·5 hot; both machines are shunt-wound, and their working conditions are 105 volts and 325 amperes at 450 revolutions. The two machines were coupled as shown in Fig. 5.

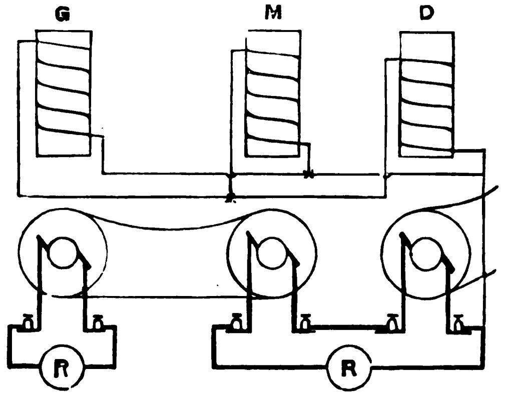

Fig. 5.

The motor M was driven from the third machine D, which was driven by an engine which is not shown in the figure. Both fields were excited direct by the dynamo D. The current through the armature of the motor M was increased gradually, so as to start it without short circuiting the dynamo D, and when the two machines had reached their full speed the generator G was made to work through a resistance frame.

Unfortunately this resistance was too small to take the load of the machines, so they had to be tested with 170 instead of 325 amperes.

The machines were also run below their normal speed. There were two reasons for this: in the first place the dynamo D could not well be driven fast enough to give 130 or 140 volts without putting on a different pulley and arranging a resistance in the shunt, and to drive the two machines so that the generator should go at its normal speed the motor would need about 20 per cent. above its normal terminal electromotive force, and about 10 per cent. more would have to be allowed for loss in the leads. In addition to this the field-magnets were excited with 128 volts instead of 105.

The readings were—

	Motor.		Generator.	
	Volts.	Amperes.	Volts.	Amperes.
	118	163	107·5	145
	117	162	106·5	145
	115	161	106·5	145
	114·8	158	105·5	142·3
Mean...	116·2	161	106·5	144·3
Speeds...	379		371	
	384		378	

the speed takers being changed over to eliminate personal errors. The fields were excited with 128 volts. Without deducting the stray power, we thus have

Power supplied to motor	18,710
Armature loss by resistance	700
Power at belt	18,010
Belt slip at 1·7 per cent	330
Given to generator	17,680
Armature loss by resistance	640
Calculated output	17,040
Actual	16,430
Stray power	610

The stray power so calculated is evidently much too small. On running the machines without any load on the generator 3,000 watts were absorbed. It is evident, therefore, that the readings, though accurate enough to serve to show the method, are not accurate enough to be taken as an example of testing. Moreover, the currents were too small, so the tests would only give the efficiency at half load. This is 86·5 for the generator. It appears probable that the machines can be tested with sufficient accuracy for all practical purposes, and perhaps more accurately than by any of the above methods, in the following way:—The machine to be tested is moted with no load, and with the field so excited that it gives the normal armature electromotive force at the normal speed. The armature volts and amperes are taken, and the product is the stray power or loss of conversion. By taking the resistance hot of the armature and fields the commercial efficiency can be calculated. Messrs. Crompton and Co. have lately made some tests to determine the efficiency of a little slow speed machine for Sir David Salomons. Some other tests were taken at the same time. The particulars of these would take up too much room, but it appears certain that the power taken to turn the machines at no load added to the loss by resistance at full load is equal to the whole loss at full load. The machines tested were very small, and at no load the readings did not always agree well. The machines took much less power when the belt was off. The discrepancies would probably hardly be noticed in large machines. With the little machines tested they were sometimes 3 per cent. or so. Taking this method of testing as correct, we may calculate the efficiency of the Crompton machines for the War Department already mentioned as follows. The two machines, separately excited, take 113 volts, and 30·5 amperes, in the motor armature. This gives 3,450 watts for the two, or 1,725 for one. The losses are then:—

Stray power	1,725
Armature resistance (hot)	3,350
Shunt (hot)	1,600
Total loss	6,675
Output	35,800
Belt power	42,475

Commercial efficiency at full load, 84·4 per cent.

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There are two points to be noticed here. One is that as the fields were very strongly excited the stray power was probably too high. The other is the very low electrical efficiency of a slow speed machine. Advocates of slow speed dynamos do not seem to realise this. A machine run at half speed has the same electrical loss, but less than half the output, so that machines like these under discussion give a low electrical efficiency because they run slow. At double the speed, they would either give a larger output or would give the same output at about 96 per cent. efficiency. It is doubtful, therefore, whether it is a good plan to use a slow speed machine at all when driven by a belt. The same type of machine driven at 700 revolutions gives an output of 110 volts, and 500 amperes at an electrical efficiency of 93·2 per cent. The practice of running slow-speed machines is strongly to be condemned. A machine running at half speed needs to be twice the size; and even then has twice the percentage of loss. It would be interesting to calculate the efficiency of the Edison-Hopkinson machines by this method. The power supplied to the two machines separately excited at no load, is, according to *The Electrician* for March 12th, 1886, 7·169 horse-power, or 5,350 watts, say 2,675 per machine. We thus have, for the generator:—

Stray power	2,675
Loss in armature	1,360
Loss in magnets	716
Total loss	4,751
Output	40,600
Power supplied by belt	45,351

Commercial efficiency, 88·2 per cent.

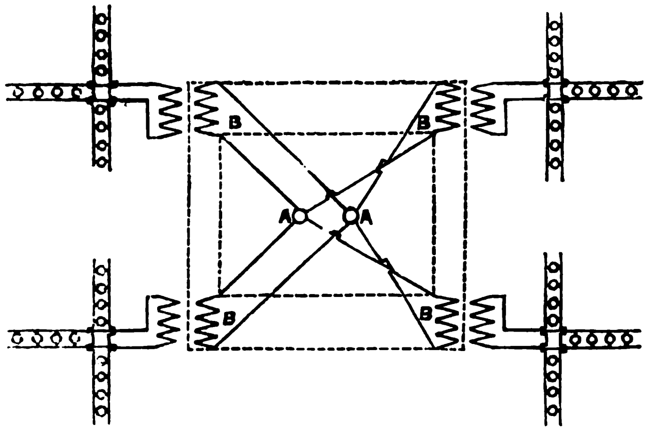
This determination does not agree with those of Drs. Hopkinson. They make out the commercial efficiency of the dynamo to be 93·23 per cent. Unfortunately the published tests of Drs. Hopkinson discrepe too much to be of use. The power spent on turning the armatures with no current is given as 7·169 horse-power, and when the full current is taken it apparently drops down to 2·22. The 93·23 per cent. is calculated from the latter figure; but what becomes of the odd, the very odd, 5 horse-power? It would be very interesting to know what electrical power it takes to drive one of these machines empty.

The accuracy with which dynamos can now be tested—thanks to Dr. Hopkinson—will allow them to be used instead of Prony brakes; and instead of the dynamometer being used to measure the power of a dynamo, we may hope to see the dynamo and motor take the place of the transmission dynamometer.

DISTRIBUTION BY TRANSFORMERS.

We learn from the *Æsterreichisch-ungarisches Patentblatt* that Messrs. Siemens and Halske propose to effect the distribution of electricity from central stations by subdividing the area to be supplied into several smaller districts, and distributing electricity in parallel mains in each such sub-district by means of large transformers, which are themselves to be supplied with current from the central station. In the publication from which we obtain these details Messrs. Siemens and Halske set forth the disadvantages attending the employment of transformers upon parallel circuits, such as the amount of copper which is required for the mains (since the potential must be kept constant and equal at every transformer on the circuit, irrespective both of the number of lamps and of transformers in use), and also the objection of bringing into the consumer's premises very nearly the full tension of the dynamo. They then refer to the difficulties connected with the regulation of transformers when connected in series, for which no solution has yet been made known, and finally they explain a method of connection by which it is proposed to obtain perfect regulation without incurring the difficulties of the parallel system. The connections proposed are shown in the accompanying figure, where A A are the terminals of the alternating current machines at the central station. Any required number of machines joined in parallel may be employed. From these points mains are carried direct to the terminals of the primary coils of the transformers (*b*) in each sub-district, and the latter are again joined in parallel by additional sub-mains, as shown by dotted lines.

Although we believe that the plan of using transformers as sub-centres of distributions is good and practical (though even this was, perhaps, scarcely thought of first in Berlin), yet as to the arrangement of the circuits it is certainly neither more nor less than a connection in parallel combined with a system of feeders such as were first employed by Edison. By splitting up the main current, a saving of copper over that required for a single parallel going all round the circuit is of course effected, but it is very doubtful whether, in any given case, this economy would not disappear by the time that the sub-mains between the several district have been provided for.*



Our chief objection, however, to the scheme, so far as it has any pretension to be considered as a step towards a general and final solution of the problem, arises from the fact that it is essentially a *central* station system. Not only must the central station be centrally situated in order to secure economy, but the transformers must also be placed in the centres of their sub-districts. From this point of view it is almost to be considered a retrograde step, for one of the chief advantages to be gained by the use of transformers arises from the facility with which, if they could but be employed on series circuits, ex-central distributing stations are immediately available. The importance of any system which admits of the use of high tension currents in a system of general distribution, so as to enable the machine to be placed upon the outskirts of the area to be supplied, is fully appreciated, but this the scheme of Messrs. Siemens and Halske does not effect.

* The authors state that the dimensions of the sub-mains will be so taken as to provide an adjustment for all ordinary discrepancies between the rates of consumption in different districts. In order to provide against *extraordinary* departures from the normal balance, they contemplate the introduction, when necessary, of resistances in the circuit of the main leads of those transformers which are doing minimum work. But it appears to us that the whole of this part of the scheme is based, to some extent, upon a misconception. In giving an illustration of the supposed action it is stated in so many words that if the potential at the machines remains constant, then the current in the main lead belonging to any given transformer tends to *increase* when the number of lamps in the secondary circuit of that transformer is ***diminished***. It is, however, tolerably well known (and it may readily be proved by theory) that the reverse is really the case. An easily-remembered rule of thumb clue to the elementary conditions of transformer circuits may be given by stating that *the virtual resistance of the primary coil varies in the same direction as the actual resistance of the secondary.* Consequently, when lamps are turned off the actual resistance of the primary is increased, and under constant difference of potential the current through the coil diminishes (instead of increasing, as stated by Messrs. Siemens and Halske). Owing to the loss of potential in the mains this decrease of current tends to cause a slight rise of potential at the terminals of the primary; but in the system under consideration this is to some extent counter-balanced by the fact that the presence of the sub-mains diverts into this route a portion of the current passing through the other primary coils. The proportion of current so diverted obviously depends solely upon the relative resistances of the various mains and sub-mains. To secure perfect compensation in this way, it is necessary that the resistance of all the mains be equal to one another, while the resistance of the sub-mains ought to be a vanishing quantity (!) In fact, as above intimated, the particular connections described have nothing to do with transformers *qua* transformers, but resolve themselves into a system of parallel mains with feeders by which the difference of potential may be kept approximately uniform at all points.

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CORRESPONDENCE.

THE PRESIDENT OF THE SOCIETY OF TELEGRAPH-ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I see that in the last number of *The Electrician* you raise the question as to who is the right man to fill the post of President of the Society of Telegraph-Engineers and Electricians in the coming year, the Jubilee of the Queen, and, as you remark, of the Electric Telegraph. You justly say that this Society ought to take the leading part in any organised effort to commemorate the Telegraph Jubilee; that they should select a president who will not only represent it with dignity, but conduct its affairs with energy and discretion; that the choice should lead to no heartburnings or humiliations, falling upon a man above the suspicion of rivalry and outside the range of jealousy.

I have nothing to say about the name you suggest, but it surprises me that you do not notice the claims of the man who by a most fortunate coincidence comes in the natural rotation. You must surely be aware that the senior vice-president of the Society was the first practising telegraph engineer in the world; that he was a pupil of Sir William Fothergill Cooke; that he is now the *doyen* of the engineers to the old telegraph companies; that he commenced his submarine experience in 1853 by laying a cable between Scotland and Ireland; that in this and the next year he laid a greater length of underground lines than has ever been laid since, besides over ten thousand miles of overground wire; that he first used a sounder as a receiving instrument, and introduced numerous improvements into the practice of telegraphy. The senior vice-president was one of the projectors of the first Atlantic cable; he was its engineer, with Mr. Cyrus Field as manager. He laid the first cables to India and in Central and South America. It was he who, with Mr. L. Clarke, in 1861, led the British Association to deal with electrical standards. His name figures in the first list of members of the Society of Telegraph-Engineers. He was a British Commissioner at the Paris Electrical Exhibition in 1881. He has served his country as a Member of Parliament. He was knighted by the Queen, and afterwards declined the offer of a baronetcy. He has nothing to gain by being president of the Society, except that deserving recognition of a useful life which confers more honour on the Society than on the individual.

The man with this splendid record is Sir Charles Tilsden Bright. By his election the Society will be represented with dignity and discretion. The choice, to use your own words, can lead to no heartburnings or humiliations, falling upon a man above the suspicion of rivalry and outside the range of jealously.—Yours, &c., GEORGE FORBES.

34, Great George-street, Westminster, December, 1886.

NOTATION, SATURATION, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I do not wish to continue a controversy unnecessarily; but in this case there are practical questions of importance at issue, and I think it desirable to say a few words more on them. As to the units. The objects of all our language, numerical and other, are to be intelligible and to avoid the risk of mistake. I maintain that the C.-G.-S. system, as used among those who write papers and read them, is the only system now in use which fulfils these requirements. The two objections to such a unit as C.-G.-S. induction per square inch are—First, that the numbers obtained are unintelligible until a process of reduction has been gone through. And this is illustrated by the fact that Mr. Kapp's own comparison of his own numbers with others appears to have led him to erroneous conclusions, as the statements he made as to the comparison could not be justified. Secondly, that it mixes up two different units in two parts of the same investigation. And surely all experience teaches that this is a method well calculated to lead to mistake. If, Sir, you wish to see C.-G.-S. abolished, there is the old English foot grain second system only lately disused. But do you really think that it is ever likely to be either so intelligible as the universal language of C.-G.-S., or so free from liability to mistake?

It is quite unnecessary to use grammes or centimetres in the workshop if you do not like them, though I have never experienced any difficulty. We speak freely in my small shop of such quantities as 10 or 20 thousand of magnetic induction, and we do not find the unit inconvenient. But that is a different question from this, of adopting mixed units in the statement of results.

Mr. Kapp's rule for the area of wire in a wound armature seems to me to be wrong, though I did not expect an error of that kind. The errors I alluded to would arise more from the impossibility of securing any accurate geometrical arrangement, or of preventing changes of figure in the section of the wire due to the force used. But the error of the rule is so serious that I append what I suppose to be the correct rule, assuming that these difficulties are neglected. Mr. Kapp's rule assumes that the layers lie on each other, as shown in Fig. 1; but that is not so. When wire is wound, the coils of each layer bed in

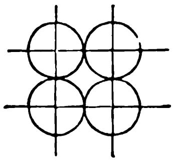

FIG. 1.

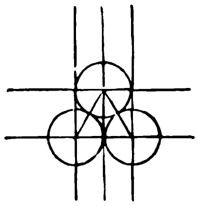

FIG. 2.

the hollows of the layer below, as shown in Fig. 2. The calculation shows that the 23,150 represented by Mr. Kapp's "25 lines" would be reduced to 20,135 by this correction. This certainly agrees well with his disc value, 20,460. But, on the whole, I am disposed to suspend my judgment as to all these values, in the absence of an account of the whole process employed.—Yours, &c.,

R. H. M. BOSANQUET.

Layers.

Distance between lines of centres of layers .... = altitude of triangle, Fig 2.
$= 2r\sin 60^\circ$
$= r\sqrt{3}$

Depth of n layers .... $= nr\sqrt{3}$ nearly.

Length of layer, m wires ...... $= 2mr$.

Section through axis of coil.

Total area occupied by mn wires $= 2\sqrt{3}\,mnr^2$

Wire area .... $= \pi mnr^2$

$$\therefore \frac{\text{Total area}}{\text{wire area}} = \frac{2\sqrt{3}}{\pi}$$

instead of $\frac{4}{\pi}$ according to Mr. Kapp; $\therefore$ the wire area, as estimated by him, is too small in the ratio $\sqrt{3} : 2$, and the estimated induction in the wire area is too large in the same proportion.

Then (having recourse to logarithms, though despised by Mr. Kapp)

$$\log\sqrt{3} = \cdot 23856$$
$$\log 2 = \cdot 30103$$

$\bar{1}\cdot 93753$ [Nov. 19, p. 38.

log equivalent of "25 lines" $4\cdot 36643 = \log 23{,}250$ (*Electrician*, [value.

$4\cdot 30396 = \log 20{,}135$ corrected

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The passage in Mr. Kapp's letter to you of last week following his graceful acknowledgement of the justice of Mr. Bosanquet's claim to priority in the matter of the "theory of

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magnetic circuits" is of a nature to invite comment. Mr. Kapp asks "why he did not apply his investigations to the practical purpose of teaching us how to design dynamo machines?" and following this are some remarks which read as if, in their author's opinion, scientific research for the mere sake of advancing knowledge was of very secondary importance. It is difficult to believe that Mr. Kapp intended them to bear this construction, but if he did not, his choice of words is unfortunate.

It may be permissible to draw Mr. Kapp's attention to the following quotation from the works of one who is admittedly the *beau ideal* of an experimental investigator, and to Prof. S. P. Thompson's remarks thereupon:—"I have rather, however, been desirous of discovering new facts and new relations dependent on magneto-electric induction than of exalting the force of those already obtained, *being assured that the latter would find their full development hereafter*" (Faraday, "Exp. Res.," § 157). The italics are now added. Concerning this passage from Faraday, Prof. Silvanus Thompson says:—"Can any passage be found in the whole range of science more profoundly prophetic, or more characteristically philosophic than these words, with which Faraday closes this section of his researches (see "Dynamo Electric Machinery," 2nd Ed. p. 224).

With such an example before him, it is scarcely to be supposed that Mr. Bosanquet will regret leaving the practical application of his discoveries to others, notwithstanding that had he done otherwise Mr. Kapp and his professional colleagues "would have been extremely grateful." Surely it is a mistake that any man naturally adapted for experimental research should devote even a part of his time to work that can be readily done by others, and, as will be generally admitted, that where there is one capable of really good experimental work, there are *twelve* who can well apply the results of such research to the good of mankind.—Yours, &c.,

99, Bishop-street, Manchester. ROBERT B. POLLITT.

THE CABLE SYSTEM.

The following letter, and the article upon it, appear in the current number of *Imperial Federation*:—

CRUISERS OR CABLES, OR BOTH?

To the Editor of IMPERIAL FEDERATION.

SIR: In your issue of November 1st there is an article entitled "Only Once in Six Years," and much is made of the terrible importance of even a few minutes' interruption of telegraphic communication at a time when war is apprehended or even during a "Russian scare."

This article, in common with many others in the daily press at this time of active company promotion, deals with the subject as if a remedy could be found, and cables laid somewhere where they could not be cut.

I ask permission to state in your columns that to entertain such an idea is to live in a fools' paradise. All cables can be cut, no matter what their length or how deep the ocean may be.

Submarine cables should be looked upon as laid for commercial purposes in the main and only incidentally for war purposes, which is the abnormal condition of great nations possessing fleets.

It is not probable they would be cut prior to a declaration of war, which no doubt would be apprehended in time for the colonies and merchants to arrange their plans for such a contingency; and our rulers should be trusted to foresee the probable contingencies and be prepared with such a plan for the concentration or disposition of their land and sea forces as could be supported by cruisers and despatch vessels, or, if need be, act without such support.

I venture to say that cables, colonies, and commerce must all take care of themselves as they best can at the commencement of any war in which this country is likely to be involved with any Power possessing cruisers until we shall have established supremacy at sea.

Is not this obvious?

Neither cables nor commerce can be guarded without cruisers, and if thousands of miles of cable are laid across broad oceans seldom traversed by our mercantile marine, is it to be expected that a fleet of armed cruisers can be told off to guard cables which can be cut any night at any number of places the enemy may select?

Both cruisers and repairing steamers watching or working in the middle of broad oceans would soon exhaust their coal supply and would always be far away from a coaling station.

If cables are to be of use in time of war for commercial purposes they must be laid along the track where our fleet and cruisers are most likely to be concentrated to guard our transports, store ships, and communications, as near the track as possible of our coaling stations and arsenals and the rendezvous of our ironclads.

Repairing steamers and large supplies of cable must be stored along these routes when war seems imminent.

It is certain that in a great war cable ships will accompany the fleet with cable for strategical purposes. Then with despatch boats and repairing ships communication will be established as soon as possible, and as soon as it is safe for our commercial marine to go freely to and fro it will be equally safe to repair cables.

What is required is more cruisers rather than more cables; but it is not to be expected that a sufficient number of cruisers will ever be available to guard cables laid across great oceans merely because they can be called, in time of peace, alternate lines.

In the interest of Federation and of commerce it is of infinitely greater value to have cheap telegraphy by lines which can be the most easily protected than to multiply lines at the expense of the tax-payers which serve no purpose other than that of ruinous competition.

My conviction is that submarine cables should only be laid in short sections, touching at as many points as possible likely to develop commerce and be of use to the world. When war is imminent the necessary provision must be made at any cost. To try and anticipate this is a waste of public money.—I am, Sir, your obedient servant, JAMES ANDERSON.

50, Old Broad-street, London, E.C., 5th November, 1886.

SHOULD A BOW HAVE ONE STRING OR TWO?

Sir James Anderson's remarks upon cable cutting, in our correspondence columns, will be read with interest as coming from a distinguished expert. "More cruisers rather than more cables" is the advice he gives. We should like to accept the one without excluding the other. With the commercial aspect of the question we are not now concerning ourselves; whether duplicate cables would really promote ruinous competition at the expense of the taxpayers does not fall within the scope of our inquiry. What we have to consider is, whether the defence of the Empire would or would not be assisted by an ocean cable route to Australia.

Sir James Anderson admits that, if war broke out to-morrow with a naval power, cables, colonies, and commerce must all take care of themselves. He means, we suppose, that cables might be cut, colonial cities shelled, and commerce smashed, the last two resulting from the first of the trio. If, however, cables remained intact, we do not imagine Sir James Anderson would deny that both colonies and commerce would have such timely notice as to enable them to mine their harbours, lay up their shipping, and man their defences. The telegraph annihilates distance and renders a surprise impossible. But cables, it is stated, can be cut, no matter what their length or how deep the ocean may be. To this we reply, that you must first find your cable before you can cut it; that to find it is much easier when the sections are short, and the charts obtainable at various stations on non-British, possible hostile territory; that, in any case, it is easier to find and to cut one cable than two; and that on the broad ocean between, say, Vancouver and Sydney, the enemy's cruiser would be further from his base and running a greater risk than is habitual with foreign vessels, when war with England is imminent. It is one thing to slip out into the Mediterranean from Toulon, or Spezia, or the Black Sea, but a very different matter to reach the Ocean cable route on the Pacific, even from Vladivostok.

After all, from the concluding sentence in Sir James Anderson's letter, we are inclined to think he differs from us only as to when the new cable route should be laid down, though in that *when* there is a mighty virtue! "When war is imminent, the necessary provision must be made at any cost; to try and anticipate this is a waste of public money." We are quite content to have the issue raised on this question of the right time, and to leave the public to decide. We advocate having two strings to our bow, so that when war is imminent we may be ready for it. Sir James Anderson wishes to wait until the last moment, and then make *the necessary provision* at any cost. But it is not long since the country had a terrible lesson, which taught that the utmost endeavour and the most lavish expenditure cannot work impossibilities, and that a moment comes when the cry goes up "Too late!" We urge such moderate and prompt expenditure of public money as may be required to subsidise an alternative ocean cable, and thus enable *the necessary provision* to be made while yet there is time.

SOCIETY OF TELEGRAPH-ENGINEERS.—Notwithstanding that our present issue contains eight extra pages, we regret that the pressure on our space compels us to leave over until next week our report of last night's meeting of this Society.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

CONTENTS.

Notes ... 69
Elementary Electricity and Magnetism—II. (Continued.) 74
Testing Dynamo Machines. By J. Swinburne (Concluded.) Illustrated ... 75
Distribution by Transformers. Illustrated ... 77
Correspondence. Illus... 78 and 79
The Cable System ... 79
REDUCTION OF CAPITAL *and* DIVIDEND ... 80
THE SOCIETY OF TELEGRAPH-ENGINEERS & ELECTRICIANS' PRESIDENTIAL ELECTION ... 81
Sur la Conductibilite Electrique des Dissolutions Salines très Etendues. By M. E. Bouty. (Concluded.) ... 81
Electromagnets.—VI. The Tension of Lines of Force. By R. H. M. Bosanquet. Illus. 83
Electric Bells. Illustrated ... 85
South Kensington Questions and Answers. (Concluded.) 85
Dynamo-Electric Machinery. By J. Hopkinson, M.A., and E. Hopkinson, M.A. (Continued.) Illustrated ... 86
The House Telephone of 1868. Illustrated ... 88
Physical Society ... 89
Proposed Bills, &c., in the next Session ... 89
Legal Intelligence ... 90
Companies' Meetings—
The River Plate Telephone and Electric Light Company ... 90
Blackpool Electric Tramway Company ... 92
Companies' Share List ... 92
Telegraph Traffic Receipts for November ... 92

LETTERS.

A letter awaits A. D.

REDUCTION OF CAPITAL *AND* DIVIDEND.

Ever since the Act of 1867 conferring on a Limited company the power to modify its Memorandum of Association there has been very little doubt as to the legality of reducing capital by special resolution of the shareholders, but it has never been suspected until now that this power extended to interest or dividend which had been definitely fixed in respect to preferential shares. Nominally, this cannot be done; but practically it can, as has just been ruled by the Court of Appeal in the case of the DIRECT SPANISH TELEGRAPH COMPANY *ats* BANNATYNE, reported in these columns last week. The judgment delivered by Lords Justices COTTON and FRY, reversing the decision of Vice-Chancellor BACON on the first hearing of the case, is of considerable importance to the mercantile world, and we are surprised that it has attracted so little attention in that portion of the Press which devotes itself specially to financial and commercial matters. To Electric Lighting companies, at a not far distant time, the subject may be of some moment; and to most of the Submarine Cable companies it is one of no small interest even now. The position of the DIRECT SPANISH TELEGRAPH COMPANY is unprecedented in some respects; but in its main features a similar contingency may arise any day with other cable companies, and the question will naturally occur to their respective shareholders, ordinary and preferential, How do we stand now that Mr. BANNATYNE'S claims have been decisively rejected on appeal?

Briefly stated, Mr. BANNATYNE, on the part of himself and the preferential shareholders in the DIRECT SPANISH TELEGRAPH COMPANY'S cables, contended that they were exempted by reason of their preferential position from the effects of a reduction of capital formally agreed upon by the majority of the proprietors and Directors of the Company. One of its two cables was lost; consequently, half its capital was dead and buried at the bottom of the sea. In these circumstances it was resolved to reduce the nominal capital to the dimensions to which misadventure had reduced the actual capital, namely, by one-half. Unhappily, there is nothing exceptional in that part of the proceedings, and it was submitted to, as sensible men of business have done before and since. But £60,000 of the capital consisted of preference shares, bearing a fixed interest at the rate of 10 per cent. per annum; and the fortunate holders of these shares, while assenting to a reduction which they had no power to prevent, not unnaturally demurred to the reduction of the preferential capital; or, more accurately, to the reduction of the 10 per cent. interest stipulated for when the preference shares were issued. We say not unnaturally, because we believe that ninety-nine people out of every hundred would suppose that the very essence of a preferential interest in such bargains as these is that it is unaffected by the risks to which an ordinary interest is liable. The contrary assumption seems to deprive the term "preference" of any meaning; and might lead to all sorts of fraudulent evasions and breaches of faith. It was partly, we believe, on the latter ground that Vice-Chancellor BACON gave judgment in favour of the preference shareholders, a decision the other way being liable to great abuse in general application, whatever might be the merits of the particular case then before him.

On more careful review of the particular case, however, the judges of Appeal have overruled the first decision, and emphatically upheld the action of the Directors, who had included the preferential capital in the general reduction. The dismissal of the original action against the company with costs will be startling news to holders of preferential stock; but on a candid examination of the facts it will be seen that substantial justice has been done. The Acts on which the preference shareholders relied are merely declaratory and permissive; and the Courts have always a discretionary power to take into account the precise reason and object of any capital reduction which one set of shareholders may approve and another set disapprove. If, said Lord Justice COTTON, it were done not honestly for the purpose of reducing capital, but for some indirect other purpose, then a question might be raised; if, on the other hand, the judge is satisfied that the creditors are duly protected, "he may," in the words of the Act 1867, "make an order confirming the reduction on such terms and subject to such conditions as he deems fit." In the present case no question could be raised as to the *bona fides* of the Directors, who simply acted in conformity with the powers granted under the Articles of Association, which were in force when the preference shares were issued, and with which the preference shareholders must be presumed to have been acquainted when they invested their money. Section 10 of those Articles empowered that reduction, and the only question remaining was whether the bargain entered into with the preference shareholders had been kept. Admitting that what had since happened was not contemplated when the bargain was made, still the bargain itself cannot be invalidated on that account, unless its terms did not cover what has unexpectedly happened.

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Now, the bargain was made by two parties, the one consenting to invest its money at a fixed rate of interest, the other consenting to receive it, but subject to its Articles of Association. These Articles, as already stated, empowered the borrowers to reduce their capital, if occasion required such a course; and the Court of Appeal has ruled that the capital invested under preferential conditions later on was subject to this contingency. No power exists, however, to reduce the preference dividend; and the sanctity of the bargain is preserved by maintaining the right to the 10 per cent. dividend originally agreed upon. In other words, the capital of preferential shareholders may be reduced like ordinary capital, but the interest may not. Owners of preference stock in the DIRECT SPANISH Cable Company will get their former rate of interest, but it will be on only half their investment. This is the net upshot of the present lawsuit; and although it is hard upon the original plaintiffs in this particular case, a ruling of an opposite kind would have been still harder upon the much more numerous body of ordinary shareholders, who otherwise might incur all the risks of an undertaking, and be compelled to deprive themselves not only of all dividends but of all their capital in order to pay a perpetual annuity, whatever happens, to the proprietors of preferential shares. "When," said one of the judges, "the resolutions reducing the capital of this company are carried into effect, the bargain, in my opinion, will be performed by giving the holders of those preference shares 10 per cent. on the then amount of their capital in the company." We should imagine that the delivery of this judgment has caused considerable flutter in the camp of preferential shareholders whose money is invested in undertakings liable to have their capital "reduced."

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS' PRESIDENTIAL ELECTION.

Some remarks of ours in last week's *Electrician* relating to the forthcoming election of president for the above Society seem to have been misunderstood. In the first place we studiously avoided making any definite recommendation on a point which, after all, finally rested with the Council; and in naming a particular person we did so, as we explicitly stated, merely by way of illustrating the possibility of finding a candidate free from most of the objections to which we made reference. It was perfectly well known that the Council up to that time had not been unanimous in their views as to next year's presidency; and our object was to suggest a course by which unanimity might be arrived at. Other courses were open; the Council might have re-elected the present president, or once more called to the chair a past president in the person of Sir W. Thomson, providing—which is by no means certain—either of these gentlemen would have consented, in the particular circumstances, to be put in nomination. It is hinted that if the Council's nominee is rejected the Council might resign. This would be an act unworthy of the Council, inasmuch as its duty, so far as the election of officers is concerned, is to advise the members rather than to dictate to them. The members are surely able to judge as to who can or who can not, in their estimation, worthily fill the office of President. The best interests of the Society are usually served by members loyally supporting the Council in the choice it makes; but *our* duty to our readers, to the profession, and to the Society is unmistakable, and it is to give expression to any such differences of opinion as have arisen in the Council, and which undoubtedly prevail among a large section of the members outside the Council. The members must then use their own judgment in the selection of a suitable candidate. We have attempted merely to give publicity to facts as they have been urged upon us. Unfortunately, the Council is not consistent in the question of rotation, or we should not be asked to support Mr. Crookes as a vice-president. Do not let us be misunderstood; we have nothing to say against Mr. Crookes, who is an eminent chemist, but in this case the Council has put aside Mr. Ansell, an old telegraphist—the senior member of the Council—to make room for Mr. Crookes. If the members are to be consistent, and support the claims of seniority, then we ought to have been told to vote for Mr. Ansell and not for Mr. Crookes. We believe we are acting in the interests of the Society by discussing the subject, the other side of which is ably treated in a communication from Prof. G. Forbes in another column.

BRITISH ASSOCIATION, 1886.

The following papers marked * were contributed to the late meeting of the British Association on various subjects connected with Electrolysis.

SUR LA CONDUCTIBILITE ELECTRIQUE DES DISSOLUTIONS SALINES TRES ETENDUES.*

By M. E. BOUTY. Abstract by OLIVER LODGE.

(*Concluded from page 63*).

IV.—*On the Migration of Ions and its Relation with the Conductivity of Salt Solutions.*

The author styles the case when the migration number of each iron is simply ½ as "normal electrolysis," and he quotes results of Hittorf to show that the salts which thus behave are anhydrous salts, *e.g.*, AmCl, KCy, KCl, K_2SO_4, K_2CrO_4, KNO_3, KBr, $KClO_3$, $KClO_4$, Ag_2SO_4, KI, $AgNO_3$.

For all these Hittorf's number (n) is very near ·5, and scarcely varies with dilution. But for salts which definitely combine with water neither of these statements holds. Here are Hittorf's numbers. S represents the weight of water combined with 1 gramme of the salt; n expresses the loss of concentration at the cathode while 1 equivalent of electrolyte is decomposed.

Salt.	S	n	Salt.	S	n
$CaCl_2$ …………	1·6974	·780	$BaCl_2+2H_2O$..	3 5	·662
	2·0683	·771		8·4	·642
	2·3608	·765		100	·614
	2 739	·749	$MgSO_4+7H_2O$..	5·3	·762
	3·9494	·727		309·6	·656
	20 918	·683	$CuSo_4+5H_2O$...	6·35	·724
	138·26	·673		9·56	·712
	229·2	·683		18·08	·675
$MnCl_2+4H_2O$..	3 306	·758		39 67	·645
	190·41	·682		148·3	
$MgCl_2+0H_2O$...	2·48	·806	$ZNSO_4+7H_2O$.	2·524	·778
	3 7	·778		4·052	·760
	22·2	·706		267·16	·636
	128·3	677	$Na_2SO_4+10H_2O$	11·77	·641
	241·3	·678		50 65	·634

It seems from this table that hydrated salts approach normality as their solutions become very dilute. They then also tend to obey the law of equivalents (k/m = const.); so the two things are connected.

"When a salt obeys the law of equivalents, its electrolysis is normal (migration number ½); when it does not obey it is abnormal, and the divergence which the law presents to the law of equivalents is so much the greater as the number n differs more from the normal value ·5. . . . There is thus, between the resistance of salt solutions and the phenomenon of migration, a very close relation, impossible to overlook."

A still more striking proof of this relation is afforded by

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some salts of which the electrolysis is not normal and does not tend to become so with increasing dilution. For instance nitrate of soda :—

	S.	n.
$NaNO_3$	2·066	·588
	2·994	·600
	34·76	·614
	128·7	·614

[The meaning of $n = ·614$ is that when an equivalent of of $NaNO_3$ is decomposed, ·614 of an equivalent is lost from neighbourhood of cathode and ·386 from neighbourhood of anode.]

The number n thus varies little with dilution, and appears rather to diverge from the normal value ·5 as dilution increases.

A comparison between $NaNO_3$ and KCl of the same concentration has furnished me with the following results :—

Concentration.	Ratio of Resist.	Ratio of Equivalents.
$\frac{1}{200}$	1·489	1·141
$\frac{1}{1000}$	1·476	

The specific resistance thus scarcely varies with dilution, and it is almost 1·3 time its theoretical value. The permanent anomaly of its electrolysis corresponds to a permanent disobedience of the law of equivalents. Salts which behave something like nitrate of soda are LiCl, NaCl, $CaSO_4$, $NaNO_3$, $NoClO_3$, $Ba2NO_3$, CaI, $Ba2ClO_3$; $Li_2SO_4 + H_2O$, $Ca2NO_3$, $+ 4H_2O$, $SrCl_2 + 6H_2O$, $NaI + 2H_2O$.

V.—*Discussion of the Results of M. Kohlrausch.*

Kohlrausch attributes to every ion a specific molecular conductivity which it preserves in every combination.

Bouty asserts that the molecular conductivity of all neutral salts in every dilute solution is the same ; and would thus consider that all the numbers of ionic velocity given by Kohlrausch should be all equal, which they by no means are.

He proceeds to criticise Kohlrausch's experiments by saying that the solutions he used were too concentrated, the weakest containing 5 per cent. of salt, while Bouty's went as low as ·025 per cent.

On the other hand Kohlrausch's tables are too comprehensive ; they include, first, acids and taric hydrates ; second, salts decomposed by water, double salts, &c.; third, neutral salts, which remain abnormal even in very dilute solution, or "abnormal salts."

The class of bodies most favourable to M. Kohlrausch's results are those relating to anhydrous and nearly "normal" salts. Here are his numbers for the following ions. The numbers for Am, K, Cy, Cl, Br, I, and NO_3 differ very little from a mean value 50. But for Ag, SO_4, ClO_3 the atomic conductivity is 40, and for CO_3 it is 36.

"To compare these numbers with my own, this is what I have done. Consider, for example, K_2SO_4 ; its molecular resistance according to Kohlrausch is

$$\frac{1}{48} + \frac{1}{40} = \frac{88}{1920}.$$

That of KCl, which I have used as a standard, is

$$\frac{1}{48} + \frac{1}{49} = \frac{97}{2352}.$$

The ratio of these is 1·1114.*

I have measured this sameratio at different concentrations—viz., $\frac{1}{20}, \frac{1}{200}, \frac{1}{1000}, \frac{1}{4000}$, and find numbers which, divided by the ratio of equivalents, give respectively

1·288 1·144 1·074 1·011.

These evidently tend towards the limit 1, and not to the number 1·1114 proposed by M. Kohlrausch.

Similarily with K_2CO_3 and $AgNO_3$.

For sulphate of silver compared with KCl, Kohlrausch's table would give 1·21, which I find by experiment ·981.

* This is a mistake. The velocity numbers themselves must be added, not their reciprocals ; so for K_2SO_4 $48 + 40 = 88$ is the conductivity, and for KCl it is 97 ; hence the ratio is 1·10. The difference being so small I have left the figures of M. Bouty unchanged, especially as the ground of his arguments is only partially affected, not removed. In a note to the September, 1886, *Journal de Physique*, p. 428, M. Bouty admits his slip.

These divergencies are not enormous, but they get much bigger if one proceeds to study normal hydrated salts whose conductivity varies so rapidly with dilution.

Kohlrausch's numbers for the following metals are very different from 50 :—

Ca 26
Ba 29
Cu 29 and 12
Mg 23 and 14
Zn — and 12

When two coefficients are given, the former belongs to ordinary salts, the other to sulphates, which otherwise M. Kohlrausch cannot get to obey his law.

Comparing these with KCl in the manner already explained, M. Bouty gets the following table, in which Kohlrausch's numbers are also inserted for comparison :—

Concentration.	$\frac{1}{20}$	$\frac{1}{200}$	$\frac{1}{1000}$	$\frac{1}{4000}$	Limit according to Kohlrausch.	
					As given by Bouty.	Corrected by O. L.
$CaCl_2$	1·437	1·339	1·251	1·181	1·428	1·29
$MgCl_2 + 6H_2O$ ...	1·339	1·277	1·131	1·029	1·549	1·34
$BaCl_2 + 2H_2O$ ...	1·290	1·133	1·081	·951	1·331	1·24
$Mg2NO_3 + 6H_2O$	—	1·323	1·249	1·163	1·581	1·4
$Cu2NO_3 + 6H_2O$	1·474	1·281	1·253	1·135	1·363	1·29
$MgSO_4 + 7H_2O$...	2·777	1·879	—	1·249	2·834	1·80
$CuSO_4 + 5H_2O$ ...	3·130	2·272	1·591	1·310	3·123	1·86
$ZnSO_4 + 7H_2O$ ...	2·924	1·923	—	1·220	3·123	1·86

"It suffices to read the numbers in any horizontal row to see that they tend towards the limit 1, not towards variable limits according to the nature of the salt. The ratios deduced from the table of Kohlrausch agree very nearly with the numbers in my first column for concentration $\frac{1}{20}$." Polarisation is so strong at the contact of metals with salts of Mg and Al that perhaps polarisation was not altogether avoided by Kohlrausch for the case of the magnesium salts above.

"To sum up: Molecular conductivities tend visibly to equality for hydrated as well as for anhydrous salts, and the disagreement of my results with those of Kohlrausch finds itself explained in the most satisfactory manner."

VI.—*Application of Faraday's Law to the Study of the Conductivity of Salt-solutions.*

"The law which I have just announced may be extended to a variety of salts. It suffices to know the manner in which the salt is electrolysed, and what quantity of salt is equivalent to KCl, for the application of Faraday's law."

The author then gives figures for various salts, classifying them thus :

a. Salts with several equivalents of acid.
b. Double salts decomposed by water (including alums).
c. Simple salts decomposed by water (tin salts and Fe_2Cl_6).
d. Stable double normal salts (K_4FeCy_6, &c.)
e. Double abnormal salts.
f. Phosphates and arseniates.
g. Bicarbonates.
h. Mercuric salts.
i. Tartar emetic and a couple of cobalt compounds.

He finds that $HgCl_2$, $HgBr_2$, and $HgCy_2$ are unique ; they are insulators. Water containing 5 grammes of one of these substances to the litre conducts very little better than pure water : 200 times less than what the k/m law would give. Sal alembroth, however, conducts.

VII.—*Organic Substances.*

Organic salts differ in no essential character from salts of which the acid and base are mineral. If the electrolysis is normal the law of equivalents rigorously applies, otherwise it does not, just as with mineral salts.

Bodies like alcohol, glycerine, glucose, urea, &c., are very bad conductors, and it is difficult to make sure that the feeble

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conductivity they show (when commercially pure) is not due to the presence of traces of salt.

VIII.—*Conductivity of very dilute Acids and Bases.*

The author has been led to the following conclusions :—

"*Acids and bases which dissolve in water without combining with it furnish insulating solutions ; on the other hand, when these substances combine with water in a manner more or less complete they conduct in the same way as salts.*

"But a given acid or a given base often forms with water several different combinations. These combinations are usually unstable in presence of excess of water ; they are dissociated more or less by elevation of temperature and by dilution. It is only in a manner altogether exceptional that a monobasic acid can exist in dilute solutions in the monohydrated state, and without mixture with superior hydrates. Its mode of electrolysis and its conductivity will vary in a corresponding manner. It is therefore not legitimate to liken acids and bases in aqueous solution to neutral salts. The law of equivalents cannot be directly applied to them."

Then follows a twelve page discussion of results to establish these laws. From this I make a few extracts only.

The case of sulphuric acid is interesting, since it can crystallise with either one, two, or four molecules of water, and it undergoes maximum contraction when combined with six atoms. It is known also to possess a maximum conductivity for sp. gr. 1·25. M. Bouty finds that the ratio λ attains a minimum for a concentration about 1/500, as the following table shows :—

Initial concentration	$\frac{1}{30}$	$\frac{1}{60}$	$\frac{1}{120}$	$\frac{1}{240}$	$\frac{1}{480}$	$\frac{1}{960}$	$\frac{1}{1920}$	$\frac{1}{3840}$	$\frac{1}{7680}$
λ	1·917	1·894	1·867	1·856	1·849	1·854	1·881	1·942	2·002

"One does not see how to explain a variation of this kind except by a change in the nature of the electrolyte (*i.e.*, of the dissolved hydrate)."

By making the hypothesis, which Bourgoin made, that the hydrate really decomposed by the current was $S_2O_6\ 6H_2O$, M. Bouty considers that the anomaly of electrolysis as expressed by Hittorf's values of *n*, and also that of conductivity, is explained. These are Hittorf's values of *n* for dilute sulphuric acid. Hydrochloric acid is in much the same condition as sulphuric acid.

*S = ·5574	1·4383	5·415	23·358	97·16	161·4
n = ·400	·288	·174	·177	·212	·206

It conducts as if its molecule contained three equivalents of basic hydrogen. One does not know such a hydrate, but there is probably a mixture of hydrates present.

Oxalic and picric acids are the best conducting organic acids. Other acids conduct hardly at all when strong, and dilution has an enormous effect upon them—probably because they combine with water forming compounds analogous to salts.

IX. *Influence of Temperature.*—To study this, the U tubes of Fig. 1 are turned upside down and immersed in a bath. The result is that for normal neutral salts the conductivity is a linear function of temperature.

$$k = k_0(1 + bt),$$

where b is the same constant for all the salts, and equal to about ·0337. This agrees with Kohlrausch also.

It is noteworthy that Poiseuille gives the quantity of water which flows through a capillary tube, under a given pressure, as proportional to—

$$1 + \cdot03365t + \cdot00021t^2.$$

It is impossible not to be struck with the identity of the principal coefficient in this formula, with *b* in the conductivity formula ; showing that resistance is of the nature of a friction, as Wiedemann surmised.

For abnormal salts the coefficient *b* is a little greater, and a parabolic formula is required at higher temperatures. So, although these salts conduct worse than normal ones to begin with, they improve faster when heated, and accordingly their abnormality decreases with rise of temperature.

For acids and bases the temperature coefficient is rather less, being only ·0119 for sulphuric acid, and ·024 for hydrochloric. Probably warming breaks up some good-conducting hydrate, and so spoils conductivity almost as fast as it otherwise improves it.

"To sum up : I believe I have established that the electrolysis of neutral salts is a simple phenomenon, and that there is only one elementary law of conductivity in harmony with the law of electro-chemical equivalents. Apparent exceptions only reveal to us the complexity of certain solutions which are not directly comparable with those of KCl or K_2SO_4."

* S means the weight of water combined with one gramme of acid.

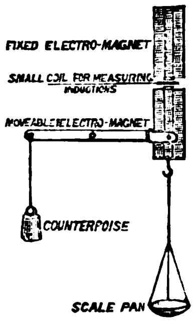
ELECTROMAGNETS.—VI. THE TENSION OF LINES OF FORCE.*

BY R. H. M. BOSANQUET.

The experimental determination of the magnetic attraction corresponding to measured values of magnetic induction has long been in my mind. It has some bearing on my theory of permeability (see *Phil. Mag.* ser. 5, XIX. 1885, p. 87 (note) and p. 94, in both of which places $\mathfrak{B}_2$ is inadvertently printed for $\mathfrak{B}^2$), but its independent interest is considerable.

After the following experiments were arranged, a paper on a somewhat similar subject was read to the Royal Society by Mr. Shelford Bidwell. From the accounts which have been so far published, the method of this paper appears to be entirely different from mine, as the magnetising force and the weight were alone directly measured ; and in other respects the method differs essentially from that which I have adopted.

The sketch represents the instrument constructed for these experiments. This consists of two cylindrical iron magnets, each 20 centim. long and ·526 centim. in diameter. Each is



wound with 1096 coils of wire. One magnet is fixed in a wooden frame, while the other moves exactly under it smoothly and without friction, between two brass collars (not shown), through a vertical distance of about a quarter of an inch. The magnets were at first ground together so as to ensure a perfect contact. The lower or sliding magnet has attached to its lower end an iron hook, which passes through the table and sustains the wooden pan for the reception of the weights. To this magnet also is firmly attached a brass collar, in which are two holes for the pivots of the beam. The beam which carries the counterpoise is about 18in. long; it moves on knife-edges, and has at one end a half-round fork, which embraces freely the collar on the lower magnet, and is pivoted thereto. On the other end of the beam is hung a lead counterpoise exactly balancing the wooden pan and magnet.

The magnetising current was sent through both electromagnets, while the induction was measured† by small coils placed round the point of contact of the two magnets. The inductions were measured by reversal. Weights were carefully added until the contact was broken, and the greatest weight sustained was taken as the observed number. This could be observed with certainty to the nearest ounce.

The first result is that the formula,

$$(W_1) \text{ weight in grammes} = \frac{S\,\mathfrak{B}^2}{8\pi\,.\,981} \text{ (S = section of contact),}$$

derived from (Vol. II.) Clerk Maxwell's "Electricity and Magnetism," p. 256, represents the values well on the whole ; but for very small inductions the weight sustained is several times as great as it should be according to this theory. And this did

* From the *Phil. Mag.* for December.

† For the method see *Phil. Mag.*, ser. 5, XIX., p. 75.

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not arise from residual induction; for when the magnetising current was interrupted, no power was left to sustain any weight at all.

I therefore framed the empirical formula W, involving both $\mathfrak{B}$ and $\mathfrak{B}^2$; this represents the lower and middle values fairly, but not the highest.

It cannot however, escape notice that the observed values are best satisfied by adding about 4oz. to all weights calculated from W_1. Since, however, this addition must vanish for $\mathfrak{B} = 0$, we cannot thus obtain a general formula. Note that the induction has been forced up to the high value of 18,500. I have shown in recent papers that this quantity has no fixed limit in bar-electromagnets. This accords to some extent with the conclusions of Mr. Shelford Bidwell in the paper before referred to.

Comparison of Observed Weights Sustained with Calculated Weights W_1 and W_2.

$$W_1 = \frac{S\mathfrak{B}^2}{8\pi . 981}, \quad \log S = \cdot 14671.$$

$$W_2 = S(\kappa \mathfrak{B}^2 + l\mathfrak{B}) \; ; \; \log \kappa = \bar{5}\cdot 55391 \; ; \; \log l = \bar{2}\cdot 76660.$$

Date.	$\mathfrak{B}$	W obs.	W_1.	Diffs.	W_2.	Diffs.
		lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
July 17.	767	0 3	0 1·2	−0 1·8	0 3·3	+0 0·3
,, 20.	894	0 4	0 1·6	−0 2·4	0 4·0	0
,, 6.	800	0 5	0 1·3	−0 3 7	0 3·4	−0 1 6
,. 8.	800	0 5	0 1·3	−0 3 7	0 3 4	−0 1 6
,, 6.	825	0 6	0 1·4	−0 4 6	0 3·6	−0 2·4
,, 17.	1,534	0 6	0 4·7	−0 1·3	0 8·6	+0 2·6
,, 20.	1,845	0 8	0 6·8	−0 1·2	0 11·4	+0 3·4
,, 8.	1,663	0 10	0 5·6	−0 4·4	0 9·7	−0 0·3
,, 17.	2,544	1 0	0 13·0	−0 3·0	1 3·0	+0 3·0
,, 8.	2,818	1 6	1 0	−0 6	1 6	0
,, 20.	3,180	1 6	1 4	−0 2	1 11	+0 5
,, 8.	3,113	1 9	1 3	−0 6	1 10	+0 1
,, 17.	3,607	1 12	1 10	−0 2	2 1	+0 5
,, 17.	4,549	2 13	2 9	−0 4	3 2	+0 5
,, 8.	5,000	3 6	3 2	−0 4	3 11	+0 5
,, 17.	5,148	3 9	3 5	−0 4	3 15	+0 6
,, 17.	5,222	3 13	3 7	−0 6	4 4	+0 7
,, 20.	5,205	3 13	3 6	−0 7	3 15	+0 2
,, 2.	5,588	4 4	3 15	−0 5	4 7	+0 3
,, 20.	7,047	5 11	6 4	+0 9	6 12	+1 1
,, 22	6 630	5 11	5 8	−0 3	6 1	+0 6
,, 8.	6,759	5 12	5 12	0	6 4	+0 8
,, 2.	6,516	5 13	5 5	−0 8	5 13	0
,, 5	6,841	6 1	5 14	−0 3	6 7	+0 6
,, 2.	6,594	6 2	5 7	−0 11	6 0	−0 2
,, 23.	7,110	6 8	6 5	−0 3	4 9	−1 15
,, 23.	7,464	6 10	6 15	+0 5	7 8	+0 14
,, 2.	7,209	6 12	6 13	+0 1	7 1	+0 5
,, 9.	6,977	6 12	6 2	−0 10	6 10	−0 2
,, 19.	6,645	7 1	5 9	−1 8	6 1	−1 0
,, 23.	7,510	7 1	7 1	0	7 9	+0 8
., 23.	7,414	7 2	6 14	−0 4	7 7	+0 5
,, 20.	8,360	8 8	8 12	+0 4	9 4	+0 12
,, 20.	9,195	10 0	10 10	+0 10	11 0	+1 0
,, 9.	8,636	10 2	9 6	−0 12	9 13	−0 5
,, 9.	9,059	11 7	10 5	−1 2	10 11	−0 12
,, 5.	11,235	15 13	15 13	0	16 0	+0 3
,, 19.	12,237	21 2	18 12	−2 6	18 12	−2 6
,, 22.	12,587	21 3	19 14	−1 5	19 13	−1 6
,, 5.	14,211	26 7	25 7	−1 0	24 15	−1 8
,, 19.	14,342	28 2	25 13	−2 5	25 6	−2 12
,, 22.	15,429	30 12	29 13	−0 15	29 2	−1 10
,, 19.	16,015	34 5	32 2	−2 3	31 4	−3 1
,, 5.	16,384	35 1	33 11	−1 6	32 11	−2 6
,, 22.	16,433	35 4	33 14	−1 6	32 14	−2 6
,, 19.	16,387	35 15	33 11	−2 4	32 11	−3 4
,, 2.	17,302	36 5	37 8	+1 3	36 4	−0 1
,, 2.	17,876	36 9	40 1	+3 8	38 9	+2 0
,, 2.	17,731	36 14	39 6	+2 8	38 0	+1 2
,, 22.	17,292	36 13	37 8	+0 11	36 3	−0 10
,, 2.	17,554	37 3	38 10	+1 7	37 4	+0 1
,, 19.	17,379	41 3	37 14	−3 5	36 9	−4 10
,, 22.	18,582	41 9	43 5	+1 12	41 9	0
,, 5.	17,596	41 12	38 13	−2 15	37 7	−4 5
,, 22.	19,519	44 3	47 12	+3 9	42 11	−1 8
,, 19.	17,905	44 5	40 3	−4 2	38 11	−5 10
,, 5.	18,497	45 0	43 13	−1 3	41 3	−3 13

The table of experiments is followed by one containing the means of the errors of the formulæ W_1 and W_2 for the groups into which the experiments are divided.

W obs.	Arithmetic mean of errors of W_1 and W_2.		Number of experiments.
	W_1.	W_2.	
lb. oz.	lb. oz.	lb. oz.	
From 0 3 to 1 6	−0 3·21	0 0·34	10
From 1 6 to 5 11	−0 3·1	+0 5·6	10
From 5 11 to 7 1	−0 5 6	−0 1·2	10
From 7 1 to 26 7	−0 9·5	−0 5·7	10
From 26 7 to 36 13	−0 4·1	−1 4·8	10
From 36 13 to 45 0	−0 11·0	−2 13·2	7

Weights Sustained by Magnets when Separated.

$$\kappa = \frac{W}{S\mathfrak{B}^2}.$$

Date.	W obs.	$\mathfrak{B}$.	κ.	Distance of magnets apart.	Mean κ.
	lb. oz.				
1886. August 2nd.	2 0	4803·5	·00002805		
	5 0	8022·1	·00002514		
	10 12	12667	·00002168		
	16 4	13893	·00002724	in.	
	17 14	14588	·00002718	·028	·00002638
	19 2	14858	·00002803		
	25 13	17464	·00002738		
3rd and 4th	1 5	3736·4	·00003042		
	3 5	6330·2	·00002675		
	7 5	9709 6	·00002510		
	10 9	11743	·00002478	·060	·00002584
	12 5	12449	·00002571		
	14 5	13878	·00002404		
	17 11	15415	·00002408		
4th and 5th.	0 7	1611·8	·00005449		
	0 10	2545·1	·00003122		
	1 5	4371·3	·00002222		
	2 5	6095·6	00002014	·2	
	2 14	6909 7	·00001948		
	3 12	8034 0	·00001880		
	5 9	10437	00001652		

Finally there are set out a few experiments made with the electromagnets not in contact, but separated to the distances mentioned by slips of card and wood. These experiments are not approximately satisfied by the foregoing formulæ; but they would agree to some extent with W_1 if, instead of the coefficient

$$\frac{1}{8\pi . 981} = \cdot 00004056,$$

we took about half that quantity, say ·000026. The experiments at distance ·2 would require a formula of the type of W_2. At present I am unable to give any explanation of these numbers.

The general truth of the law

$$\text{Tension} \propto S\mathfrak{B}^2$$

is sufficiently established.

In my theory of permeability I have assumed the tension within the magnetic body $\propto \mathfrak{B}$. It is clear that this assumption leads in that case to consequences which correspond with reality, and that the assumption tension $\propto S\mathfrak{B}^2$ does not do so in that case. I am at present unable to explain the divergence between the two points of view.

The weights have all been reduced to lbs. and ozs. to facilitate comparison with the actual experiments.

Batteries were used for weights up to about 5lb.; the dynamo from about 2lb. upwards.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of this company during the month of November was 3,076, estimated to produce £2,550, against 2,707 messages, producing £2,313 in the corresponding month of last year. The traffic receipts for the month of August, estimated at £2,200, realised £2,163.

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ELECTRIC BELLS.

The great interest that was taken in our articles on Electric Bells, and which has been shown more recently in the lectures at the City and Guilds Institute, leads us to think that the following particulars of improvements will be welcomed. The improved designs—actual specimens of which we have before us—are by Mr. Walker Moseley, and refer perhaps more to the indicators connected with the bells than to the bells themselves. The type described and illustrated is that known as the mechanical replacement system. This name is given to a class of indicators which are actuated by electricity only to *expose* the signal or announcement, and not to replace it in its normal position, the replacement being by means of mechanical cams, levers, &c., of various types of construction.

The advantages claimed for this class of indicator are (1) That a larger semaphore may be exhibited with a weaker current than would be required for operating the movement in both directions. (2) Less electrical knowledge is required in fitting. The illustrations show, A the solenoid, B one half of the iron core on which the solenoid is fixed, C the other half of the core, hollow to contain the coiled spring D, and movable so that the projection E opposes the latch L and prevents the disc K from falling.

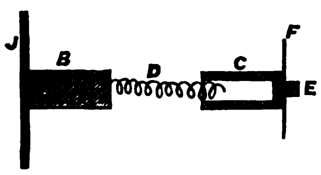

FIG. 1.

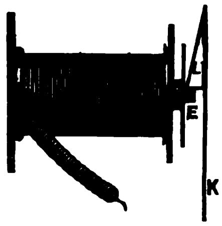

FIG. 2.

The circuit is completed through B, C, G, F, H, J, and it will be observed that the electric current has to produce a force sufficient only to resist the coiled spring D, which is of silver wire, No. 45 B.W.G. Although the spring is so slight it appears impossible for any harm to happen to it becasue it is so completely enclosed.

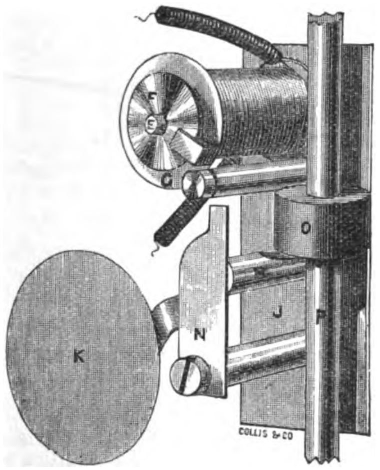

FIG. 3.

The mechanism for replacing the semaphore to its normal position is simple. The vertical bar P carries as many flexible rubber cylinders O as there are indicators in a vertical line. A portion of pivoted cylinder M is cut away, as shown in Fig. 3. The bar P being pulled downwards causes M to rotate the cylinder M about a quarter circle, which causes the latch L to pass over the projection E (Fig. 2), which springs forward again, and holds up the semaphore until another current is passed through the solenoid.

SOUTH KENSINGTON EXAMINATIONS.

HONOURS EXAMINATION.

(Concluded from page 498, Vol. XVII.)

44. Describe and explain fully the experiments and calculations needed for determining the electro-chemical equivalent of an electrolyte.

A.—The electro-chemical equivalent of an electrolyte is defined to be the mass of the electrolyte decomposed in a unit of time by a current of unit strength; or, taking a gramme and a second as the units of mass and of time respectively, and the ampere as the unit of current, the electro-chemical equivalent is equal to the number of grammes decomposed in a second by a current of one ampere.

The quantities to be determined are therefore

The strength of the current	$=C$
The time during which the current flows	$=t$
The weight of the electrolyte decomposed	$=M$

and the electro-chemical equivalent E will be

$$E = \frac{M}{C\,t}$$

These determinations may be made directly in the case of the electrolyte considered, but the products of the decomposition cannot be measured with equal accuracy in all cases, and besides this, the accurate experimental determination is a long process, involving a very large number of measurements of great delicacy, and therefore it is better to determine the electro-chemical equivalent of some suitable substance such as silver, and then to deduce from this the electro-chemical equivalents of other substances.

This we can do when we know the chemical equivalent of the substance, from the law discovered by Faraday—that the electro-chemical equivalents of different substances are proportional to their chemical equivalents (the chemical equivalent of a substance being the quotient of its atomic weight by its valency).

The methods of making the voltameter measurements in the case of silver are described in the abstract of Messrs. Kohlrausch's paper on page 253 of the present volume, and therefore they need not be repeated here. The measurement of the duration of the current presents no difficulty. There remains then the measurement of the strength of the current. This may be done directly by means of an electro-dynamometer, or a tangent galvanometer may be used, and it is then necessary, in addition to knowing the galvanometer constants, to determine the value of the horizontal component of the earth's magnetism at the position occupied by the galvanometer, and at the time of each observation. The authors of the paper above mentioned used three different methods for determining the value of the horizontal magnetic intensity.

(1) *Gauss's Method.*—(1) The time is observed of the vibration of a magnet suspended by a single fibre and performing horizontal oscillations under the influence of the earth's magnetism. This gives the value of the product M H when the moment of inertia of the magnet and the coefficient of torsion of the fibre are known, M being the magnetic moment of the magnet, and H the horizontal intensity of the earth's magnetism. (2) The direction of the magnetic north having been determined, a small magnet is suspended by a fine silk fibre, and the magnet of moment M is placed with its centre at a distance r from that of the suspended magnet, in the same horizontal plane, and due magnetic east for one observation, and due magnetic west for another, and with its axis magnetic east and west. Observations may be made in each position with the north pole of M to the east and to the west respectively, giving four observations for one value of r.

If θ be the deflection observed, the value of the ratio M/H may be found from the approximate formula

$$\frac{M}{H} = \frac{r^3}{2} \tan \theta.$$

Several series of observations may be made in this way with different values of r.

Another series of observations may also be made by placing the magnet M with its centre due magnetic north and south respectively of the centre of the suspended magnet, and with its axis magnetic east and west, when the approximate formula will be

$$\frac{M}{H} = r^3 \tan \theta.$$

The value of H will therefore be obtained by eliminating M by means of the two final equations, which give the values of MH and M/H.

(2) *The Bifilar Magnetometer Method.*—In this method, referred to on page 254 of the present volume, the earth's action on the magnet is determined by suspending it bifilarly, and measuring the torsion required to keep it at right angles to the magnetic meridian, and the deflection it produces in another magnet is observed at the same time. This method does not require a determination of the moment of inertia of the magnet, and no measurements of time are required.

(3) *The Bifilar Galvanometer Method.*—This is similar to the last method, with the exception that the magnet attached to the bifilar suspension is replaced by a coil of wire carrying a current, and therefore the magnetic moment of the magnet is replaced by the product of the strength of the current traversing the coil into the total area included by all its turns—that is to say, the sum of the areas included by each separate turn.

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When the value of H has been obtained by one of these methods its small variations with the time must be determined, and also the small differences for the different positions occupied by the instruments, as described in the abstract already referred to, which also describes the various precautions and corrections which are required to insure the greatest possible accuracy.

Lord Rayleigh, in his determination of the electro-chemical equivalent of silver (*Philosophical Transactions*, 1884, Part 2), measured the intensity of the current by means of an electrodynamometer with two parallel and equal fixed coils. The readings were always taken of the deflection of the bifilarly suspended small coil on reversing the direction of the current in the fixed coils, which eliminated the effects of terrestrial or other permanent magnetism, and also the action of other parts of the circuit on the suspended coil. It also insured that the heating effect of the current on the fine copper suspending wires of the moveable coil, and any consequent alterations in their mechanical properties (which might alter the restoring force of the bifilar system), should be the same in both sets of readings, and would therefore be eliminated from the result.

45. Explain the sense in which the term "Absolute" is used in connection with measurements of electrical magnitudes. Describe and explain an experimental method of determining, in absolute measure, the resistance of a conductor.

A.—Absolute Measurements.—Measurements of electrical or other magnitudes are called absolute when they are expressed in terms of units which depend only on the three fundamental units, viz., those of time, length, and mass. Results expressed in absolute measure are therefore independent of any quantities depending on the instruments employed, or on the time and place of observation.

Absolute Measurement of Resistance.—The determination in absolute measure of the resistance of a conductor, giving, as it does, an absolute standard of resistance, is one of the most important of electrical measurements, and has therefore been carried out by various physicists. The first determination was made by Weber (see *Phil. Mag.*, 1861), who used two distinct methods.

Weber's First Method.—By suddenly turning a coil of wire about an axis so as to alter its position with regard to the lines of terrestrial magnetic force, a momentary E.M.F. was generated in the coil. A fixed coil in connection with the movable coil had a magnet suspended at its centre, the deflection of which, due to the momentary current, was observed.

The total E.M.F. depends on the dimensions of the movable coil and the terrestrial magnetic intensity, and can be determined in terms of them. The total current is measured by the impulse given to the magnet, the mechanical value of which is measured by the angle of deflection. The resistance of the circuit, consisting of the two coils, is then found by dividing the E.M.F. by the current.

Weber's Second Method.—A powerful magnet was made to oscillate within a coil of wire. The motion of the magnet produces currents in the coil whose reaction on the magnet retards its motion. The resistance can then be determined by comparing the rates of diminution of the amplitude of the oscillations with the circuit closed and with the circuit open respectively.

Sir William Thomson's Method.—This method was used in the determination described in the report of the British Association Committee on Electrical Standards, in 1862. (The reports of the committee are collected in one volume published in 1873).

A coil of wire is made to revolve with constant velocity about a vertical diameter. The motion of the coil across the terrestrial lines of force produces induced currents in the coil whose direction in the coil is reversed at every half turn, viz., when the plane of the coil passes through the E and W direction. Considering the direction of the current with regard to a fixed line in this direction, we see that the direction of the current with regard to either aspect of this line remains unchanged, or, in other words, the direction of the current in space is constant. A magnet suspended at the centre of the coil will therfore be deflected in the direction of its revolution. The force producing this deflection is continually varying, but it is periodic, and its periodic time is small, and therefore the deflection may be made sensibly steady by giving sufficient mass to the suspending apparatus. The E.M.F. of the moving coil, and the current in it, may both be determined in terms of the horizontal magnetic intensity when we know the dimensions of the coil, its angular velocity, and the deflection of the magnet. The resistance of the coil is the ratio of these two quantities, and the measurement of the resistance is independent of the magnetic intensity, which disappears from the ratio. This method was used, with some improvements in details, by Lord Rayleigh in his determination of the Ohm in absolute measure. (*Proc.* Roy. Soc., May, 1881.)

Prof. G. Carey Foster has modified Sir William Thomson's method by using an independent galvanometer to measure the current instead of using the coil itself as a galvanometer, and the conductor, whose resistance is given by the experiments, is entirely distinct from the revolving coil. The chief advantage of this modification is that the conductor whose resistance is to be measured being at rest, may be a coil of wire of any material, and may be immersed in a bath of known temperature. It also enables us to experiment upon independent coils of different resistances. The method is described in detail in the British Association Report for 1881, and in the *The Electrician*, Vol. VII., page 266.

DYNAMO-ELECTRIC MACHINERY.

By J. Hopkinson, M.A., D.Sc., F.R.S., and E. Hopkinson, M.A., D.Sc.

(Continued from page 65.)

A very important problem is to deduce the characteristic curve of a series wound machine from the normal characteristic; in this case $c = C$, and we have

$$1 + \frac{-1}{\nu} 4 \lambda m C \frac{A_2}{2 l_2} = F \left\{ \left(4 \pi n - \frac{4 \lambda m}{\nu} \right) C \right\}$$

taking P R as ordinate of any point in the normal characteristic, cut off Q R equal to $\frac{\nu - 1}{\nu} 4 \lambda m C \frac{A_2}{2 l_2}$, that is, draw O Q so that

$$\tan Q O x = \frac{\nu - 1}{\nu} 4 \lambda m C \frac{A_2}{2 l_2} \Big/ 4 \pi \left(n - \frac{m \lambda}{\nu \pi} \right) C$$

$$= \frac{\nu - 1}{\nu \nu} \frac{A_2}{2 l_2} \frac{\lambda m}{\pi n - \frac{\lambda m}{\nu}}$$

then P Q will represent the induction corresponding to magnetising force $4 \pi \left(n - \frac{m \lambda}{\nu \pi} \right) C$. It is noteworthy that as the current C, and therefore O R increases, P Q, the induction, will attain a maximum and afterwards diminish, vanish, and become negative. That in series wound machines the E.M.F. has a maximum value has been many times observed. The cause lies in the existence of a waste field not passing through the armature, and in the saturation of the magnet core.

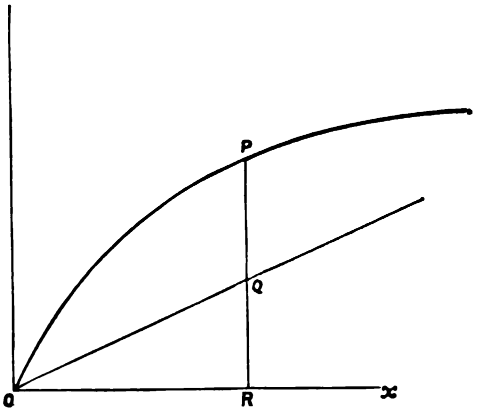

Fig. 6.

The effect of the current in the armature on the potential between the brushes of any machine is the same as that of an addition to the resistance of the armature proportional to the lead of the brushes, and to the ratio of the waste field to the total field, combined with that of taking the main current $\frac{m \lambda}{\nu \pi}$ times round the magnets in direction opposite to the current c.

The preceding investigation tells the whole story of a dynamo machine, excepting only the relation of λ to C in order that the brushes may be so placed as to avoid sparking. The only constant or function which has to be determined experimentally for any particular machine is ν, the ratio of total to effective field, all the rest follows from the configuration of the iron and the known properties of the material.

The following illustrations of the effect of the current in the armature and the lead of the brushes are interesting. In both cases the magnet coils are supposed to be entirely disconnected so that c is zero. First, let λ be negative, short circuit the brushes and drive the machine at a certain speed, a large current will be produced, the current in the armature itself forming the magnet.* Second, let λ be positive, cause a current to pass through the armature, the armature will turn in the positive direction and

* Added August 17th.—This experiment was tried upon a dynamo machine of construction generally similar to that shown in Figs. C, D, E, but with an armature of half the length intended in normal work to give 400 amperes 50 volts at 1,000 revolutions. The magnet coils were disconnected, and the terminals of the armature were connected through a Siemens electro-dynamometer, and the machine was run at 1,380 revolutions. When the brushes were placed in the normal position

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will act as a motor capable of doing work. In either case, particularly the former, such use of the machine would not be practical owing to violent sparking on the commutator. The following is a further illustration of the formula given above. If we could put up with the sparking which would ensue, it would be possible to make λ negative in a generator of electricity, and thereby obtain by the reactions of the armature itself all the results usually obtained by compound winding.

Efficiency Experiments.

Having discussed the relations subsisting between the configuration of the magnetic circuit of a dynamo machine and the induction obtained for given magnetising forces, and having compared the results obtained by direct calculation with the results of actual observation on a particular machine, the construction of which we have described at length, it appeared of importance to determine the efficiency of the machine under consideration as a converter of energy, when used either as a generator of electricity or as a motor. An accurate determination of the mechanical power transmitted to a dynamo by a driving belt, or of the power given by a motor presents formidable experimental difficulties. Moreover, if the mechanical power absorbed in driving the dynamo be measured directly, any error in measurement will involve an error of the same magnitude in the determination of the efficiency. To avoid this difficulty, we employed the following device.

Let two dynamos, approximately equal in dimensions and power, have their shafts coupled by a suitable coupling, which may serve also as a driving pulley; and let the electrical connections between the dynamos be made so that the one drives the other as a motor. If the combination be driven by a belt passing over the coupling pulley, the power transmitted by the belt is the waste in the two dynamos and the connections between them. By suitably varying the magnetic field of one of the dynamos, the power passing between the two machines can be adjusted as desired. If, then, the electrical power given out by the generator is measured, and also the power transmitted by the belt, the efficiency of the combination can be at once determined. By this arrangement the measurement, which presents experimental difficulties, viz., the power transmitted by the belt, is of a small quantity. Consequently, even a considerable error in the determination has but a small effect on the ultimate result. On the other hand, the measurement of the large quantity involved, viz., the electrical power passing between the two machines, can without difficulty be made with great accuracy.

The second machine was similar in all respects to that already described, and each is intended for a normal output of 110 volts, 320 amperes, at a speed of 780 revolutions per minute.

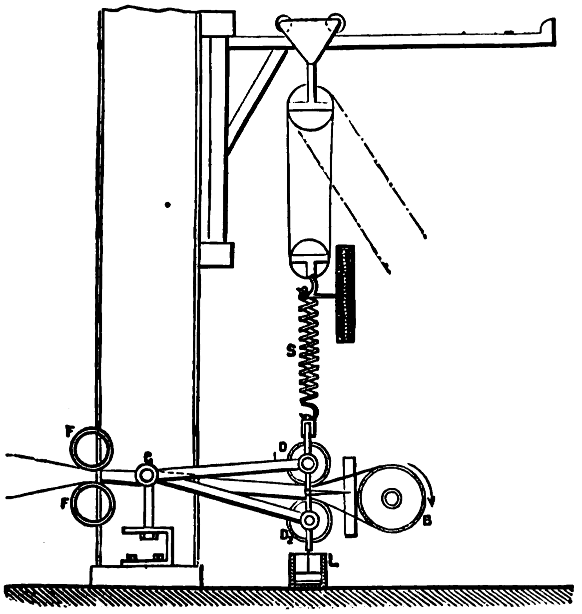

FIG. F.

The power transmitted by the belt was measured by a dynamometer of the Hefner-Alteneck type, the general arrangement being as shown in Fig. F. A is the driving pulley of the engine, B the driven coupling of the dynamo; D, D are the guide pulleys of the dynamometer carried on a double frame turning about the fulcrum C, and supported by a spiral spring, the suspension of which can be varied by a pair of differential pulley blocks attached to a fixed support overhead. When a reading is made the suspension of the spring is adjusted until the index of the dynamometer comes to a fiducial mark on a fixed scale; the extension of the spring is then read by a second index attached to its upper extremity. F, F are two fixed guide pulleys of the same diameter as the pulleys D, D, and having the same distance between their centres, in order that the two portions of the belt may be parallel, and the sag as far as possible taken up. The normal from C to the centre line of either portion of the belt between the pulley A and the guide pulleys = 31·9 cms. The normal from C to the centre line of either of the parallel portions of the belt = 2·4 cms.; and from C to the centre line of the spring = 92·7 cms.

($\lambda = 0$) the current due to the residual magnetism was 52 amperes. By giving the brushes a small positive lead the current was reduced to nearly zero. By giving the brushes a small negative lead a current of over 234 amperes, the maximum measured by the dynamometer, was obtained, and by varying the lead it was easy to maintain a steady current of any desired amount.

Take moments about C; then

$$\text{Tension of the belt} = \frac{92{\cdot}7}{34{\cdot}3} \times \text{tension of the spring.}$$

$$= 2{\cdot}7 \times \text{tension of the spring.}$$

Also the diameter of the pulley B = 33·6cms. and the thickness of the belt = 1·6cm.

Hence the velocity of the centre of the belt in centimetres per second = 1·845 × revolutions of dynamo per minute, and, therefore,

Power transmitted by the belt in ergs per second

$= 2{\cdot}7 \times 1{\cdot}845 \times 981 \times$ tension of spring × revolutions per minute,

assuming the value of g to be 981.

We may more conveniently express the same power in watts ($= 10^7$ ergs per second), and write

Power in watts = ·0004887 × tension of spring × revolutions per minute.

The potential between the terminals of the generator was measured by one of Sir William Thomson's graded galvanometers, previously standardised by a Clark's cell, which had been compared with other Clark cells, of which the electromotive force was known by comparison with Lord Rayleigh's standard. The current between the two machines was measured by passing it through a known resistance, the difference of potential between the ends of the resistance being determined by direct comparison with the Clark standard cell, according to Poggendorff's method. As experiments were made with currents of large magnitude, it was important that the temperature coefficient of the resistance should be as low as possible. To this end we found a resistance frame constructed of platinoid wire of great value. The temperature coefficient of this alloy is only 0·021 per cent. per degree centigrade. (*Proc.* Roy. Soc., Vol. XXXVIII., p. 265, 1885.)

The resistances of the armatures and magnets of the two machines are as follow:—

		Ohms.
Generator	armature	0·009947
	magnets	16·93
Motor	armature	00·9947
	magnets	16·44

The resistance of the leads connecting the two machines was 0·00205 ohm, and of the standard resistance 0·00586 ohm.

In all determinations of resistance, the value of the B.A. ohm was taken as $0{\cdot}9867 \times 10^9$ C.-G.-S. units, according to Lord Rayleigh's determination.

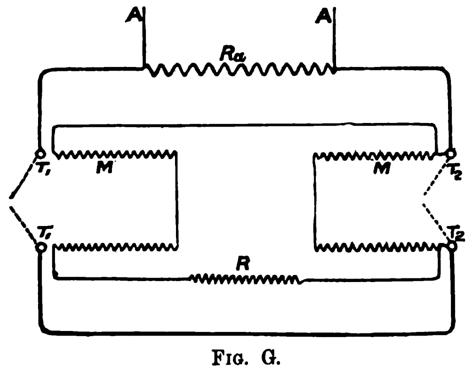

FIG. G.

R_a resistance for measuring current; R resistance for adjusting field of motor; M M magnet coils; A A connections to Poggendorff's bridge; T_1 T_1 terminals of motor; T_2 T_2 terminals of generator.

Fig. G shows the electrical connections between the two machines with the rheostat r inserted in the magnets of the motor dynamo.

In order to ascertain the friction of bending the belt round the pulley B, and of the journals of the dynamo, a preliminary experiment was made with the dynamometer. The combination was run at a speed of 814 revolutions per minute with the dynamos on open circuit and the tension of the spring observed—9,979 grammes. The engine was then reversed, and the dynamos run at the same speed and the tension of the spring again observed—3,629 grammes. The difference of the two readings gives twice the power absorbed in friction, viz., 1,262 watts for the two machines, or 631 watts per machine. This is excluded entirely from the subsequent determinations of efficiency, as being a quantity dependent on such arbitrary conditions as the lubrication of the journals, the weight of the belt, and the angle it makes with the horizontal.

In Table I. column I. is the speed of the dynamos; column II. is the reading of the spring in grammes; column III. is the power transmitted by the belt in watts; column IV. is the potential at the terminals of the generator; column V. is the current passing in the external circuit between the two machines; column VI. is the resistance introduced into the magnets of the motor by the rheostat; column VII. is the power absorbed in the armature of the generator; column VIII. is the power absorbed in the armature of the motor; column IX. is the power absorbed in the magnets of the generator; column X. is the power absorbed in the magnets

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TABLE I.

—	I. Revs. per min.	II. Grms.	III. Watt.	IV. Volts.	V. Amps.	VI. Ohms	VII. Watt.	VIII. Watt.	IX. Wts.	X. Wts.	XI. Watt	XII. Watts.	XIII. Watt.	XIV. Watts.
1	810	8,392	3324	129·1	21·6	1·39	13	4	984	861	110	4,720	676	5,396
2	801	9,299	3642	127·2	72·0	1·39	75	62	955	770	130	10,678	825	11,503
3	811	11,113	4413	125·8	150·0	2·72	267	223	935	825	294	21,014	935	21,949
4	808	10,433	4116	124·4	186·0	2·72	394	344	914	695	387	25,256	691	25,947
5	792	10,660	4124	116·5	211·0	2·72	501	445	801	608	454	26,592	657	27·249
6	798	16,897	6595	110·6	351·0	4·59	1317	1231	722	581	1099	41,567	822	42,389
7	764	17,690	6604	110·12	358·0	4·09	1360	1274	716	472	1117	42,086	831	42,917
8	766	17,804	6669	110·6	360·0	4·59	1335	1296	722	452	1151	42,451	856	43,307
9	778	16,556	6300	102·3	369·0	4·09	1443	1361	618	396	1176	40,304	653	40,957
10	756	20,412	7537	96·8	446·0	4·59	2070	1978	554	348	1668	46,242	459	46,701
11	808	9,526	4758	119·3	36·8	2·72	394	344	855	636	211	7,011	1009	8,020
12	802	—	1512	113·5	No curr't	...	...	...	...	...	..	...	756	...
13	814	3,175	1262	...	...	...	...	...	...	...	...	...	631	...

TABLE II.

—	I. Per cent.	II. Per cent.	III. Per cent.	IV. Per cent.	V. Per cent.	VI. Per cent.
1	0·25	18·23	12·52	69·0	71·44	40·44
2	0·65	8·30	7·17	83·88	69·9	58·63
3	1·235	4·27	4·27	90·22	89·68	79·9
4	1·52	3·53	2·66	92·29	92·78	85·63
5	1·84	2·94	2·415	92·81	93·70	86·51
6	3·11	1·70	1·94	93·25	93·79	87·45
7	3·17	1·65	1·94	93·23	93·37	87·05
8	3·08	1·67	1·98	93·27	93·99	87·26
9	3·525	1·51	1·59	93·37	94·02	87·49
10	4·47	1·20	1·00	93·39	93·62	87·43
11	0·31	3·53	2·66	92·29	92·78	85·63

of the motor; column XI. is the power absorbed in the connecting leads between the two dynamos, in the rheostat resistance r, and in the standard resistance used for measuring the current; column XII. is the total electrical power developed in the generator; column XIII. is half the power absorbed by the combination less the known losses in the armatures, magnets, and external connections of the two machines; column XIV. is the total mechanical power given to the generator, being the sum of the powers given in columns XII. and XIII.

In Table II. the percentage losses in the armature and magnets of the generator are given, as also the sum of all other losses as obtained from column XIII. in the foregoing table; also the percentage efficiency of the generator, of the motor, and of the double conversion. Column I. is the percentage loss in the generator armature; column II. is the percentage loss in the generator magnets; column III. is the percentage sum of all other losses in the generator; column IV. is the percentage efficiency of the generator; column V. is the percentage efficiency of the motor; column VI. is the percentage efficiency of the double conversion.

In this series of experiments in all cases, from Nos. 1 to 10 inclusive, the brushes, both of the generator and motor, were set at the non-sparking point; but in No. 11 no lead was given to the brushes of the generator, and, consequently, there was violent sparking throughout the duration of the experiment.

In No. 12 the magnets were separately excited with a current giving 113·5 volts across their terminals. The power absorbed must be due entirely to local currents in the core of the armature, and the energy for the reversal of magnetisation of the core twice in every revolution of the armature.

No. 13 gives the results of the experiments on the friction of the bearings and in bending the belt already referred to.

It will be observed that the figures in column XIII. are calculated by deducting the power absorbed in the armatures and magnets, and extraneous resistances from the total power given to the combination as measured by the dynamometer. They must therefore include all the energy dissipated in the core of the armature, whether in local currents or in the reversal of its magnetisation; also the energy dissipated in local currents in the pole-pieces, if such exist; also the energy spent in reversing the direction of the current in each convolution of the armature as they are successively short circuited by the brushes. Further, it will include the waste in all the connections of the machine from the commutator to its terminals and the friction of the brushes against the commutator. A separate experiment was made to determine the amount of this last constituent, but it was found to be too small to be capable of direct measurement by the dynamometer. Moreover, from the manner in which the figures in this column are deduced, any error in the dynamometric measurement will appear wholly in them. Since, undoubtedly, the first two components enumerated are the most important, and the conditions determining their amount are practically the same throughout the series, the close agreement of the figures in the column are a fair criterion of the accuracy of the observations. Probably 100 watts is the limit of error in any of the measurements. Such an error would affect the determination of the efficiency when the machines were working up to their full power to less than ½ per cent.

It has been assumed that the sum of these losses is equally divided between the two machines. This will not accurately represent the facts, as the intensities of the fields and the currents passing through the armatures differ to some extent in the two machines. The inequality, however, cannot amount to a great quantity, and if it diminishes the efficiency of the generator it will increase the efficiency of the motor by a like amount, and contrariwise. In No. 11 of the series the effect of the sparking at the brushes of the generator is very marked, the power wasted amounting to at least 250 watts.

If it be assumed that the dissipation of energy is the same whether the magnetisation of the core is reversed by diminishing and increasing the intensity of magnetisation without altering its direction, or whether it is reversed by turning round its direction without reducing its amount to zero, a direct approximation may be made to the value of this component. (J. Hopkinson, *Phil. Trans.*, Vol. 176 (1885), p. 455).

The core has about 16,400 cubic centims. of soft iron plates, hence loss in magnetising and demagnetising when the speed is 800 revolutions per minute $= 16{,}400 + \frac{800}{60} + 13{,}356$ ergs per second $= 292$ watts.

Referring to Table II. it appears that the efficiency approaches a maximum when the current, passing externally between the two machines, is about 400 amperes. Let C be the current in the armature, ρ its resistance, W the power absorbed in all parts of the machine other than the armature, then if the speed is constant, the efficiency is approximately $\frac{E C - W - C^2 \rho}{E C}$, where E is the electromotive force. This is a maximum when $\frac{W}{C} + C\rho$ is a minimum, which occurs when $W = C^2 \rho$; when the loss in the armature is equal to the sum of all other losses. For the machines under consideration the experimental results verify this deduction. But in actual practice the rate of generation of heat in the armature conductors, when a current of 400 amperes was passed for a long period, would be so great as to trench upon the margin of safety desirable in such machines. Of the total space, however, available for the disposition of the conductors, only about one-fourth part is actually occupied by the copper, the remainder being taken up with insulation, and the interstices left by the round wire. If the space occupied by the copper could be increased to three-fourths of the total space available, while the cooling surface remained the same, the current could be increased 75 per cent. and the efficiency increased 1·3 per cent. approximately, as all losses other than that in the armature wires would not be materially altered.

The loss in the magnets is also susceptible of reduction. It has already been shown that for a given configuration of the magnetic circuit and a given electromotive force the section of the wire of the magnet coils is determinate. The length is, however, arbitrary, since within limits the number of ampere convolutions is independent of the length. An increase in the length will cause a proportionate diminution in the power absorbed in the magnet coils. If the surface of the magnets is sufficient to dissipate all the heat generated, then the length of wire is properly determined by Sir William Thomson's rule that the cost of the energy absorbed must be equal to the continuing cost of the conductor.

(To be continued.)

THE "HOUSE" TELEPHONE OF 1868.

In the accompanying illustration, which we reproduce from the *Scientific American*, is shown an instrument which, although not designed for the purpose, yet actually constitutes an efficient telephone transmitter and receiver, and was patented by Mr. Royal E. House in the year 1868. For the following particulars respecting this instrument and its inventor we are substantially indebted to some articles which have recently appeared in the columns of our contemporary above referred to. Mr. House, who was born in the year 1806, and who is still living, was engaged in the early development of the electric telegraph in America, and was working on parallel lines with Prof. Morse. In 1868 he patented the instrument here figured, under the title of "Improvements in Electro-Phonetic Telegraphs," the idea being to obtain a highly-sensitive apparatus capable of working as a sounder with very small currents, and so doing away with the necessity of using relays and repeaters upon Morse circuits. Although the instrument does not appear to have come into actual operation, there can be no doubt that it was perfectly capable of fulfilling the purpose required. If, indeed, Mr. House had fully perceived the extreme delicacy of his apparatus, the discovery of Prof. Bell would have been anticipated by eight years.

With regard to the instrument itself, its construction is so clearly shown in the figure that a verbal description would be superfluous. The object of the rod which is attached to the

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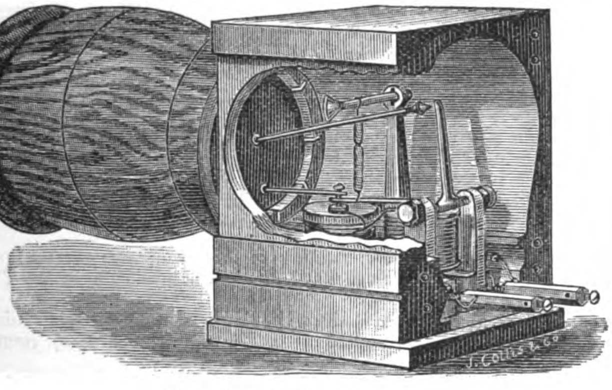
lower part of the diaphragm, and which the inventor termed a "limiter," was to prevent the armature from receding too far from the poles, for which purpose its extremity is provided with an adjustable stop. Probably, however, this particular detail has no special value. The motion of the armature contemplated by the inventor was only one-hundredth of an inch. Unfortunately, the model which was deposited in the United States Patent Office was accidentally destroyed by fire, but a pair of instruments constructed in accordance with the specification and patent drawings when used as transmitter and receiver are said to give results "immeasurably superior to anything shown in the Bell patents of 1876 or 1877." We are further told that "sibilants are as clearly transmitted as any other sounds, and its work was fully as good as that of the Bell telephone and Blake transmitter of to-day."



The House Telephone.

The instrument will shortly be introduced as a commercial article by the Wallace Telephone Company, of New York.

PHYSICAL SOCIETY.—Nov. 27.

Prof. W. G. ADAMS in the Chair.

The following papers were read:—*On a Method of Measuring the Coefficient of Mutual Induction of Two Coils*, by Prof. G. CAREY FOSTER, F.R.S. The two coils are for convenience designated by P and S (primary and secondary). The method, as originally devised, consists of two parts. (1) Observing the swing of the needle of a galvanometer needle placed in series with the secondary coil when a current of strength γ is started in the primary. (2) Placing the galvanometer and a condenser of known capacity c as a shunt between two points, A and B, of the primary circuit, such that the first swing of the galvanometer needle, on completing the primary, is the same as in (1). It is easily seen that under these conditions $M=crr_1$, where M is the coefficient to be determined, r=resistance between the points A and B, and r_1 = resistance of galvanometer and secondary coil. The method requires the value of γ to be the same in the two experiments, and facilities for varying r without altering γ. To overcome these difficulties, the arrangement has been modified so as to make it a null method. The connections remain the same as in (2), excepting that the ends of the secondary coil are connected to the terminals of the galvanometer through a variable resistance with no self-induction. If p be the resistance of the secondary coil, and variable resistance when adjusted, so that on completing the primary circuit the integral current through the galvanometer is zero, it is shown that $M=cpr$, where c and r have the same meaning as before. For let A and E be the potentials of the galvanometer terminals at any time t, y the resistance of galvanometer, q the current through it, and N and L the coefficients of self-induction of the galvanometer and secondary coil respectively. Then considering the path from A to E through the secondary coil we have $$A-E=px+L\frac{dx}{dt}-M\frac{dy}{dt};$$
for path through galvanometer
$$A-E=qy+N\frac{dy}{dt}.$$
Equating these and integrating from $t=0$ to $t=\infty$ we get
$$p\int_0^{\infty} x\,dt - My=0.$$
Since $\int_0^{\infty} x\,dt$=charge of condensor, $=C\,y\,r$, we see that $M=cpr$.

It is easily shown that if $L=M$, then $A-E=0$ for all values of t. Hence the galvanometer might in this case be replaced by a telephone.

By inversion, the method could be used for determining the capacity of condensers in absolute measure, if M be known. The author thinks the method will be useful for dynamo machines, and gave a series of numbers obtained by experiments on different coils, showing that it gives consistent results. Mr. C. V. Boys suggested that by arranging a switch to change the connections from (1) to (2) in rapid succession a steady deflection might be obtained, and thought that this would enable very small coefficients to be determined. Remarks by Prof. Forbes, Prof. Adams, and Prof. Perry were answered by Prof. Foster and Dr. Fison.

On the Critical Mean Curvature of Liquid Surfaces of Revolution, by Prof. A. W. RÜCKER, M.A., F.R.S. The paper is chiefly mathematical, and deals with liquid surfaces of revolution attached to two circular rings, the planes of which are at right angles to the line joining their centres. By "mean curvature" the author designates: *Half the sum of the reciprocals of the two principal radii of curvature of the surfaces.*

Maxwell has shown in his article on "Capillary Action" ("Enc. Britt.") that if the film be a cylinder, a slight bulge will cause an increase or decrease in the mean curvature according as the length is $<$ or $>\frac{\pi}{2}$ times the diameter. If $l=\frac{\pi}{2}d$, then a small change in the volume of the surface will modify its form, but will not alter the mean curvature. Thus the mean curvature of such a cylinder is evidently a maximum or minimum with respect to that of other surfaces of constant mean curvature, which pass through the same two rings at the same distance apart, and which differ but little from the cylindrical form. Hence the cylinder may be said to have a *critical mean curvature* when the distance between the rings is $\frac{\pi}{2}$ times their diameter. If the distance between the rings is altered a similar property is possessed by some other surface. The author's paper investigates the general relation between the magnitude and distance apart of the rings and the form of the surfaces of critical curvature.

If x is the axis of revolution, then the equation to a liquid surface of revolution is given by the expressions
$$x=\alpha E+\beta F, \quad y^2=\alpha^2\cos^2\phi+\beta^2\sin^2\phi,$$
where F and E are elliptic integrals of the first and second kinds respectively, of which the amplitude is ϕ and the the modulus $K=\sqrt{\alpha^2\beta^2}/\alpha$.

As usual $\triangle=\sqrt{1-k^2\sin^2\phi}$, whence $y=\alpha\triangle$; and if $K=\sin\theta$, then $\beta=\alpha\cos\theta$, and since $\alpha>\beta$, α and β are the maximum and minimum ordinates.

The results show that as θ increases from 0° to 90° the surface of critical mean curvature is an unduloid with limits of cylinder and sphere, when $\theta=0$ and $\theta=90°$ respectively. When θ passes from 90° to 180° the surface is a nodoid, with limits of sphere, and a circle whose plane is perpendicular to the surface of revolution. In the third quadrant the surface is still a nodoid, the limits of which are a circle and the catenoid. Finally, in the fourth quadrant the surface is an unduloid, the limits being the catenoid and cylinder. Experiments were shown proving that with cylindrical films, where $l<\frac{\pi}{2}d$, increase of internal pressure produced a bulging, whereas if $l>\frac{\pi}{2}d$, a bulging was produced by decrease of pressure. From this it is evident that if the interiors of two cylindrical films whose $l<\frac{\pi}{2}d$ be connected, stable equilibrium will result; whereas if $l>\frac{\pi}{2}d$ there will be unstable equilibrium. These facts were illustrated experimetally with great success. After some remarks by Mr. C. V. Boys the proceedings terminated.

PROPOSED BILLS, &c., IN THE NEXT SESSION.

The West Metropolitan Tramways Company notify their intention of applying to the Board of Trade for a Provisional Order, to be confirmed by Parliament next Session, to empower the company and others using their tramways to work them by means of carriages and engines propelled by electricity or other power, in addition to or in substitution for animal power. Authority will be asked for to empower the Board of Trade to make, and the company to enforce by-laws, &c., for regulating the use of electricity or other power.

The Northampton Street Tramways Company will make a similar application.

Notification is given of an intended application to the Board of Trade by a company to be incorporated as the Littlehampton Electric Tramway Company, or by Magnus Volk and others, for a Provisional Order to enable them to make a tramway at Littlehampton from the railway station there along the roads to the esplanade at Littlehampton, and to work the tramway by electric motive power, "or by such other power as the Board of Trade may approve."

In the Bill for which the Weston-super-Mare Improvement Commissioners intend to apply to Parliament power will be asked for to provide and maintain for their town hall, offices, and other establishments, telegraphic and telephonic communication with any parts of the district.

The Cockermouth Local Board will apply to Parliament for leave to bring in a Bill to enable them to produce and supply electricity for all purposes within certain limits to be defined, and for that purpose on any land for the time being belonging to them to make and maintain works for the production, storage, supply, and distribution of electricity for the purposes of light, heat, and motive power, and to exercise with respect thereto all or any powers of the Electric Lighting Act, 1882, the Gasworks Clauses Act, 1847, and the Gasworks Clauses Act, 1871, and other rights and powers

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which may be necessary or expedient for the purposes in question. By other clauses the Board will ask for powers to purchase the undertaking of the Cockermouth Gaslight and Coke Company, by agreement or compulsorily, and also to enable them to acquire, hold, and use patent rights and licences for and in relation to the production, storage, and supply of electricity, the manufacture, supply, and use of gas, and the manufacture and conversion of residual materials and products.

LEGAL INTELLIGENCE.

The Anglo-American Brush Electric Light Corporation (Limited) v. R. E. Crompton and Co.

This was an appeal heard by Lords Justices Cotton and Bowen on behalf of the defendants from an order of Vice-Chancellor Bacon, which was made in chambers on the 2nd Nov. this year, directing them to deliver further particulars of objections in addition to those particulars of objections already given by them to the plaintiffs pending an action for infringement of patent.

Mr. Butcher appeared for the appellants ; Mr. G. C. Graham representing the Company.

The former opened his case by saying that the action was one for an infringement of the patent granted to the plaintiffs' predecessors in the year 1878 for the construction of dynamo electric machines. The patent was amended by disclaimer in 1885, and the action was commenced. The defendants put in their defence. They denied the validity of the patent, and they had also delivered the particulars of the objections on which they intended to rely at the trial, those objections having been delivered on the 11th August last. The objections, he might say, were a plea of invalidity, want of utility, and insufficiency of specifications, and last an objection, which was the most material in the case, as to what was called disconformity, which was stated in the usual way, as far as he had been able to discover, and which said "that the alleged invention, described in the complete specification as amended, was a different invention from that described in the provisional specification " It was with regard to this latter objection that the present appeal was lodged. His contention was that the question of conformity or non-conformity was one to be decided on the construction of the two specifications, and to ask the defendants for any further particulars of objection than had been already furnished, and which, he believed, fulfilled all the statutory requirements, was in reality to ask them to disclose the nature of their defence at the forthcoming trial. The order really amounted to this:—"What are the heads of the arguments by which you intend to ask the Court, as a matter of law, to say that the final specification varies from the provisional?" It appeared to him that the plaintiffs could not possibly be taken by surprise. They knew the precise objection that was raised against them, and if they were prepared with evidence to construe their patent they would be ready to meet any objection.

Their Lordships having heard the arguments of Mr. Butcher, both concurred, without calling upon the other side, in declining to interfere with the order of the lower Court.

Gilman v. The Gulcher Electric Light and Power Company.

This was an appeal by the plaintiff from that portion of the judgment of Mr. Justice Grantham, who tried the case without a jury, which disallowed his claim for fees as a director of the defendant company in respect of the period from the 31st December, 1884, to the 14th of May, 1885, when he resigned his position as a director.

The case was heard last Friday by the Master of the Rolls and Lords Justices Lindley and Lopes. Mr. Candy, Q C., appeared for the plaintiff, the defendant company being represented by Mr. L. E. Pyke

Mr. Candy opened his case by saying that by the Articles of Association of the Company the remuneration of the Directors was fixed at the lump sum of £1.500 per annum, which should be divided between the members of the Board in proportion to their attendances, or as they may determine. By certain calls on the plaintiff's shares, which were not disputed, the amount sought to be recovered was reduced to £64. 7s. 6d. Mr. Gilman was very willing to go to meetings after December, 1884, but the other Directors were so hostile to him that they threatened to break his head, and to break up every meeting at which he attended, and consequently he resigned. At the trial he was prepared, if necessary, to adduce evidence in support of that statement, but his learned friend, Mr. Pyke, said it was quite immaterial, because he rested his contention, which was successful with Mr. Justice Grantham, upon the wording of Article 52 of the Company's Articles of Association, which he read. At the time Mr. Gilman joined the Board, the principle of division of the £1,500 was to give to the Chairman £500, and to each of the remaining four Directors £250. He then proceeded to read several minutes of the Board passed at various times, waiving part of the Directors' fees, and apportioning the remainder among the members of the Board, the effect of which was to deprive the plaintiff of the amount claimed.

The Master of the Rolls, without calling upon the other side, in delivering judgment, said that he agreed with the ruling of the learned judge who tried the case. The plaintiff became a Director of the Company under certain Articles. According to these Articles he had a right to a certain remuneration. The true construction of Article 52, dealing with the remuneration of the Directors, was that they were to receive £1,500 per annum. That was what the Company undertook to pay. So far as the present dispute was concerned the Company were not bound to pay at all. "The remuneration shall be £1,500 per annum, and shall be divided between the members proportionately to their attendances, or as they may determine." There was no limitation as to time. If there was no resolution of the Board to alter that Article the remuneration was to be in proportion to their attendances. Now, what would happen in the case of a Director who had shown no attendances? Nothing could be paid in that case, and yet the £1,500 would have to be divided. Having regard to the construction of the Article how that £1,500 was to be distributed, it was absolutely within the discretion of the Directors, and they had, by resolution, come to a determination upon it. It was said it was *ultra vires* to come to the determination because it was after Mr. Gilman had ceased to be a Director. But he could see nothing which said that the Board which came to the determination was not the Board. On the contrary, it was the Board. It was said that they behaved with gross injustice to the plaintiff. His answer to that was that he could not help it. There was nothing laid before him that led him to suppose that it was unjust. Very likely there were good reasons for it. He did know. If they said, "Your conduct has been such that we cannot associate with you," he saw nothing unjust in that. But probably because of that there might be the ground of an action against the Directors, but not against the Company. But if a Director stayed away for a whole year and the other Directors appropriated the money that he otherwise would have had, he saw nothing unjust in that, because the extra work, in consequence of that non-attendance, was thrown entirely upon the other Directors. He therefore upheld the judgment of the learned judge.

Lord Justices Lindley and Lopes also concurred.

COMPANIES' MEETINGS.

River Plate Telephone and Electric Light Company (Limited).

An extraordinory general meeting of this Company was held at the offices, 34, Walbrook, on the 1st inst., under the presidency of Mr. Thomas Lloyd.

The Secretary (Mr. R. Rodgers) having read the notice convening the meeting, the minutes of the last meeting were taken as read, confirmed, and signed by the Chairman.

The Chairman then said that as the amalgamation or sale to be submitted for the shareholders' approval depended on the terms of the agreement which had been come to, the most satisfactory course would be for the solicitor of the Company to state all the essential points of the agreement, so that the shareholders might understand what was submitted to them.

Colonel Gouraud thought that as much as possible of the agreement should be read, of course leaving out the "whereases."

The Solicitor (Mr. Godlee) said he would leave out nothing that was of importance. The agreement was made between this Company, the United Telephone Company of the River Plate, and Mr. Rodgers on behalf of the new company to be formed, and to be called the United River Plate Telephone Company (Limited). The Consolidated Telephone Company and Mr. Frank Williams Jones were also parties to the agreement for the purposes of the last clauses. The agreement recited that it was proposed to effect an amalgamation of the businesses of the River Plate Company and the United Company for the transfer thereof to the new company. With that view it was intended that each of the two companies should pass special resolutions for voluntarily winding up and appointing liquidators. It also recited that the new company was about to be incorporated, and that a Memorandum and Articles of Association had been prepared. Those Articles had been signed subject to such modifications as might be agreed upon by all the three companies who were the principal parties to the agreement, and it was recited that the Consolidated Company were largely interested in the River Plate Company, and that Mr. Jones was a director of, and largely interested in, the United Company. The operative part of the agreement was as follows:—"This agreement is conditional on two things—the passing of the special resolutions aforesaid within six weeks from the date hereof (that is the 22nd November) and the adoption of this agreement by the liquidators of the two companies and by the new company in such a manner that it should become binding on them respectively before the 1st of January next, subject, as aforesaid, that each of the two companies should sell and transfer the good will of its business in the Argentine Republic and Paraguay, and the assets mentioned, to the new company, who should purchase and take over the same." Having read the assets of the River Plate Company, and of the United Company, which were to be transferred, he said that the consideration for the sale and transfer was as follows:—To the River Plate Company and to the United Company £145,000 each ; the new company will also pay in cash to the United Company the cost price of the whole of the new telephones, &c., which had not been used.

The Chairman said that this particular clause was put in because the United Company carried on a sale business, which the River Plate Company did not. But the new company was not to be bound to take over more than £10,000 worth of such stock, and Mr. Jones, who was Chairman of the United Company, though he did not bind himself to the figures, expressed the belief that the amount of stock would be between £8,000 and £10,000.

The Solicitor (continuing) said that the new company was also to pay the United Company in cash a sum not exceeding £3,000 on account of certain items which he read. Of the consideration to be paid to each company £20,000 was to be satisfied by the issue to each company of 200 debentures of the new company for twenty years at 7 per cent., and the new company had the right at any time after the 1st January, 1892, to pay off those debentures at the expiration of six calender months' notice by paying a bonus of £10 per cent. each. Each company

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also agreed to accept £40,000 in fully paid up ordinary shares in the new company at par, and such further portion of the balance of £125,000 as the new company might desire to pay in shares instead of cash. The new company, within twenty days after its incorporation, was to offer to the public for subscription at least 34,000 of its £5 shares, and to use its best endeavours to place them. The special clause to which Mr. Jones and the Consolidated Telephone Company were made parties was the last clause, by which they agreed that they would not directly or indirectly compete with the new company in the Argentine Republic or Paraguay, or assist any other person or company to carry on any opposition to, or compete with, the new company in those Republics for ten years from the date of the agreement, the new company, in consideration of this agreement, agreeing that in case Mr. Jones died or ceased to be a member of the Board of the new company before its annual meeting in 1891, the new company would pay to him, his executors, &c., a sum at the rate of £166 per annum from the date of his ceasing to be a Director up to such annual meeting, together with the same proportion of all sums above £1,500 which should be payable to the Directors of the new company from his ceasing to be a Director to the said annual meeting, as he would have received if he had still remained a Director of the new company. The schedule consisted simply of the form of debentures.

The CHAIRMAN presumed that they would not require that to be read.

Mr. C. L. W. FITZGERALD said that he understood the £20,000 of debentures referred to would simply go to the old debenture holders.

The CHAIRMAN said that that was so.

Mr. FITZGERALD said that the old debenture holders were giving up 2 per cent. of their interest under the agreement.

Colonel GOURAUD stated that he was asked to attend the meeting on behalf of several shareholders in the Company, who took their interest in it when he was Chairman of the Company, which he ceased to be two years ago. It was thought by those gentlemen that the information given in the circular was meagre. He could quite appreciate that it would have been difficult to go into very many details without giving the text of the agreement to the shareholders, which perhaps for some reasons would not have been expedient. He certainly would like to have an opportunity of reading the agreement, but not in such a way as one would go through it at a meeting and then hand it back.

The CHAIRMAN said he would remind Colonel Gouraud that a confirmatory meeting had to be held a fortnight hence, and that the present meeting committed itself to nothing except the principle. In the interval the shareholders would have had further time to consider the subject.

Col. GOURAUD said he was aware that there would be a confirmatory meeting, but he thought that all information possible should be given at the first meeting. With that object he would therefore ask one or two questions. He had been unable to take any of the assets which the River Plate Company would turn over to the new company and compare it with the language used by the Solicitor in reading the next clause referring to the assets to be turned over by the United Company. As to the Articles of Association of the new company, that was a very important matter, and he thought the shareholders should have the opportunity of judging for themselves what those Articles were by being able to read them. By these remarks he was far from wishing to imply that he had any want of confidence in the work of the Directors, or what they recommended the shareholders to ratify. He had from his own experience in the Company a very keen appreciation of the difficulties which the Directors must have had in bringing the negotiations with the competing (the United) company to a head. With all his experience he had never met with any gentleman so difficult to negotiate with as Mr. Jones, who was so keen to his own interests. As he understood it, the Directors had accomplished what the old Board strove constantly for two years to do. Mr. Jones seemed now to be getting a good many extras, but perhaps he was entitled to them; and the provision as to salary in the event of his ceasing to be a Director was unusual. But probably there was reason for that. As to the shares in the new company, he presumed that the amount of the shares as indicated as the amount to be offered to the public was settled with reference to the questions of a Stock Exchange quotation, and so on. He also suggested that provision might be made enabling shareholders in the present companies to have a preference in the taking up of the shares of the new company, providing that that could be done without their risking the obtaining a quotation on the Stock Exchange. Great progress had been made in the past in the face of extraordinary competition, and he believed himself that they would have a marvellous future. The Consolidated Company and Mr. Jones had agreed as to not competing with the new company for ten years; but he did not see why the arrangement should not be indefinite for not competing. He thought it would be advantageous if the meeting could be adjourned for a day or for a couple of hours.

The CHAIRMAN said that, as regarded an adjournment beyond the 1st of December, Christmas was very close upon them, and it was thought desirable that the new company should not be postponed to months hence in the new year. They had to hold a confirmatory meeting, and he thought it was obvious that they could not adjourn the meeting beyond that day. They had called the meeting at the earliest opportunity and they found themselves tied by time. With regard to the point about the stores, the shareholders were probably aware that the River Plate Company only did an exchange business, whereas Mr. Jones's company did a sale business as well. He had sold to the new company his exchange business and also his sale business, and it was thought only reasonable, as he had a stock of material on hand for selling purposes, that that stock should be taken over at cost price.

Colonel GOURAUD asked what cost price meant.

Mr. JONES replied that the cost price was the invoice prices that the Company paid for the material. They paid, for instance, £3 for a complete telephone.

The CHAIRMAN said that one of the objects in view was a quotation of the shares.

Mr. QUILTER, M.P., understood that the stock that was to be taken over was efficient material.

The CHAIRMAN said that that was the case.

Mr. FITZGERALD pointed out that the agreement stated that th stock was to be new and unused.

Colonel GOURAUD said he believed that it was the intention of Mr. Jones that the material should be such as could be used in the prosecution of the business.

Mr. JONES assented, and added that in the event of any question arising as to any material there would be no objection raised to the point being referred to an arbitrator.

The CHAIRMAN said that the reason for the proposed payment to Mr. Jones, in the event of his ceasing to be a Director, was that Mr. Jones conceived that in being asked to guarantee that he would not compete with the new company he was asked to do something out of the ordinary, and as the Directors had some experience of Mr. Jones's enterprise and ability in competing with them, and they were very anxious that in the future if that gentleman ceased to be a Director they should not have to face the same formidable competition, they made the arrangement with him referred to in the agreement.

Colonel GOURAUD expressed himself satisfied with the explanation.

The CHAIRMAN said he thought he had already answered the point of what was to be transferred from the two companies to the new company. Practically, the two companies turned over their whole exchange business, and Mr. Jones's company, in addition, turned over the sale business. The latter received precisely the same price as the River Plate Company, except that the new company would take over at cost price the material in hand which Mr. Jones had for sale. The provisional agreement made early in the year in Buenos Ayres stipulated that the amalgamation in Buenos Ayres should take place on the 1st of March last. When they met finally to conclude the agreement the question arose whether they should go back to the 1st of March or fix a present or future term for the amalgamation, and, on the whole, they had thought it better to fix on the date mentioned in the agreement. The shareholders would remember that if they went back to the 1st of March they would have to hand over the whole of the receipts since the 1st March to the new company, and the new company would not have any benefit from the great reduction in the expenses which they hoped would result from the amalgamation. As the business, however, of both companies had been extended since then, and as the new company would benefit by the extension, it had been judged only fair that the expenditure in extending the business should be paid for. That was to say, if they had done more in extending the business than Mr. Jones's company they would get paid for what they had done in excess of that gentleman's company, and *vice versâ*.

Colonel GOURAUD said that was a very reasonable arrangement.

A SHAREHOLDER wished to know whether either company had obtained all the concessions in the important towns in the Argentine Republic.

Mr. JONES replied in the negative, and added, as a matter of fact, that there would come into the possession of the new company a sales contract in connection with a new company which was to be started at Rosario.

The SOLICITOR said that there was a difference in the assets of the two companies to be handed over. The two clauses in the agreement referring to that matter were identical, except that the United Company handed over its business in Uruguay to the new company, while the River Plate Company did not do so. The United Company would also hand over its sale contracts with their benefits and obligations.

The CHAIRMAN, in answer to Mr. Quilter, said that Mr. Jones guaranteed that he would not compete with the new company, and the new company except his sale contracts, took over nothing in Uruguay. The River Plate Company retained its business in Uruguay, and the new company bought nothing there but Mr. Jones's sale contracts. He was sure that the Consolidated Telephone Company would strongly object to guaranteeing that it would not sell or do business in Uruguay.

Mr. QUILTER said that his object was not to prohibit the Consolidated Company, but as he understood they were taking over Mr. Jones's sale business in the Argentine Republic, and that part of the world, he presumed that it was intended that Uruguay, as far as Mr. Jones was concerned, should be included in it.

The CHAIRMAN said that as a matter of fact it was not so included, Mr. Jones having said that he would guarantee only as far as the Consolidated Telephone Company guaranteed. Mr. Jones, however, handed over his sale contracts for ten years, and the price he got was the first five years' profits. If there was no profit he got nothing, and therefore if he competed with the company he would practically put the price out of his own private pocket.

Mr. QUILTER said that his suggestion was in view of future harmony being secured.

Mr. JONES said he thought there were far more reasons for the new company to anticipate opposition from the Consolidated Telephone Company than from himself.

Mr. FITZGERALD thought that that remark was not just. The Consolidated Company was giving up a good business which they were doing on the River Plate; but they would most distinctly object to agree not to supply instruments to Monte Video. If Mr. Jones wanted the Consolidated Company to do that all that he (the speaker) could say was that he must stand up for the shareholders of that company. If Mr. Jones liked to add the word "Uruguay" as regarded his (Mr. Jones's) company, he thought he could do so.

Mr. JONES considered it quite a bagatelle, and would consent if he were requested.

Mr. FITZGERALD said there was one matter which the Chairman had not put exactly before the meeting. The capital of the River Plate Com-

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pany he believed was about £92,000. They were selling that business in Buenos Ayres, which had cost a considerable sum of money, for £125,000. Whether in shares or cash would depend very much indeed on the way the public took the shares. But he thought he might say the result would be that the shareholders in this old company would also have a very considerable sum of money returned to them in cash, and also a certain sum which would be the amount according to the rules of the Stock Exchange that they could have in shares. If any gentleman in the room wished to apply for shares in the new company he was perfectly entitled to do so as well as the public, but the absolute result would be, as far as he could make out, that they would get in shares about half a share each for each share they held, and in cash about £4. 11s., and also the back dividends. That was the result that he worked out, and it would come to something like £8 a share.

The CHAIRMAN said that he had not all the data before him for giving an estimate, and the meeting must take Mr. Fitzgerald's estimate on the responsibility of that gentleman alone.

Mr. QUILTER, in answer to Colonel Gouraud, intimated that if any privilege were given to the shareholders in connection with applying for shares of the new company, which the general public did not enjoy, the risk would be run of a Stock Exchange quotation not being granted.

Colonel GOURAUD presumed that the Articles of Association and agreement would be open to the shareholders between the present and the next meeting.

The CHAIRMAN: Certainly.

Colonel GOURAUD said he took it that the liquidation was somewhat unusual, as the River Plate Company were selling only a portion of their business, while they were retaining a very important business in Monte Video, which would be confided to the management of the liquidators. He did not know how far a meeting such as this could control liquidators in that way, but he would like to have some expression of opinion as to what their intentions were in regard to the business that was to be retained.

Mr. QUILTER said he thought it would be better to deal with that matter when the question of liquidators arose.

The CHAIRMAN then said that the first resolution he had to propose had reference to the appointment of liquidators, and was as follows:—"That it is expedient to effect an amalgamation of this Company, except as regards its Uruguay business, with the United Telephone Company of the River Plate (Limited), and that with a view thereto this Company be wound up voluntarily, under the provisions of the Companies Acts, 1862 to 1883, and that Thomas Lloyd, of 34, Walbrook, E.C., Esquire, and C. L. W. Fitzgerald, of 4, Hercules-passage, E.C., Esquire, be and they are hereby appointed liquidators for the purposes of such winding up, at a remuneration to be fixed by the Company."

The CHAIRMAN continuing, said that since the notice was sent out Mr. Grewing wished to withdraw, and Mr. Fitzgerald agreed to take his place.

At the suggestion of Mr. QUILTER it was decided to divide the resolution into two parts, the first part ending at the figures "1883."

On the motion of the CHAIRMAN, seconded by Major FITZGERALD, this resolution was agreed to; as was also subsequently the latter part as to the appointment of liquidators, on the motion of the CHAIRMAN, seconded by Mr. R. E. BATEMAN.

Mr. QUILTER asked what control the shareholders had over the liquidators.

The SOLICITOR said that the liquidators had the same power as the Directors, and they could summon a general meeting. He believed they were in the same position as Directors, and they were bound to hold a meeting once a year.

The CHAIRMAN then proposed the next resolution, as follows:—"That there be conferred upon the liquidators all the powers which can be conferred upon liquidators under the provisions of the Companies Act."

Major FITZGERALD seconded the motion.

Mr. QUILTER asked whether any extraordinary powers were proposed to be given to the liquidators.

The CHAIRMAN: Our legal adviser says no.

Colonel GOURAUD inquired whether any powers could be reserved.

The SOLICITOR: They are the ordinary powers of liquidators.

Colonel GOURAUD said the liquidators might have to carry on for years the business that was retained.

The SOLICITOR replied that the liquidators were bound to summon a general meeting every year.

Mr. QUILTER said that the liquidators could not be removed except by an order of the Court.

The SOLICITOR replied that that was so.

The resolution was altered by the addition of the following words:—"With the assistance of a consultative committee consisting of the following gentlemen, with power to add one to their number"—the gentlemen selected being Mr. Quilter and Mr. Arthur Baker, of the Stock Exchange.

On the motion of Mr. R. E. BATEMAN, seconded by Colonel GOURAUD, a resolution was passed to the effect that the remuneration of the two liquidators should be £500 between them.

The CHAIRMAN then proposed the following resolution:—"That the agreement expressed to be made between the Company, of the first part, the United Telephone Company of the River Plate, of the second part, Richard Rodgers on behalf of the United River Plate Telephone Company, Limited, which is about to be incorporated, of the third part, the Consolidated Telephone Construction and Maintenance Company, Limited, of the fourth part, and Frank Williams Jones, of the fifth part, be and the same is hereby approved, and that the liquidators be and they are hereby directed to adopt the said agreement on behalf of this Company, and to carry the same into effect."

Major FITZGERALD seconded the motion.

At the instance of Mr. Fitzgerald the following words were added to the end of the resolution:—"With power to agree to such modifications in the Articles of Association of the new company as they may think fit."

The resolution as thus altered was unanimously agreed to.

On the motion of Colonel GOURAUD, seconded by Mr. QUILTER, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN acknowledged the vote, and said it was only fair to Mr. Jones, that gentleman having been referred to, to say that he (the Chairman) had found him, while extremely clever, at the same time a very fair and courteous negotiator. He had never met an abler negotiator, but he never asked to meet a fairer one.

The proceedings then terminated.

Blackpool Electric Tramway Company.

The second annual meeting of the shareholders in this Company was held on Saturday, Mr. R. Horsfall, mayor of Halifax, presiding. In moving the adoption of the report, which recommended that a dividend of 5 per cent. be paid, and that £800 be set aside as a reserve fund (the report was given verbatim in our last issue), the Chairman said that he met the shareholders with very much more confidence than he did at their last meeting. They had overcome many difficulties in the working of the line during the year, and he thought they had now got everything in a satisfactory condition, and that the Company had been placed upon a sound basis. The Company had not met with that support from the inhabitants of Blackpool, and the Corporation especially, which it was entitled to; and the Directors had been compelled to appeal to the Board of Trade on the question of running the cars on Sundays—a proceeding which the Corporation had very strongly objected to. £100 was voted to the Directors, and a vote of thanks to Messrs. Elwell-Parker and Co. for their numerous and valuable services to the Company was unanimously adopted. The dividend was declared, and the retiring Directors, Messrs. Morris (Halifax), Moseley (Manchester), and Oddie (Halifax), were re-elected.

BUSINESS NOTICE.—Mr. C. E. Zimdars, Telegraph Engineer of London and New York, asks us to state that his business address is No. 327, Gray's Inn-road, W.C., and not Hatton-garden.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Dec. 1.		Business Done Week Ending Dec. 1. Highest.	Lowest.
Anglo-American	37,	38	38	36¾
Do. Preferred	60,	61	60⅝	59
Do. Deferred	14⅞,	15⅛	15 1-16	13¾
Brazilian Submarine	10⅜,	11⅛	11⅛	10⅜
Cuba	11,	11½	11 1-16	11
Do. Preference	18,	19	—	—
Direct Spanish	2,	2½	—	—
Do. Preference	9½,	10½	—	—
Direct United States Cable	9⅜,	9⅝	9½	9 1-16
Eastern Telegraph	10¼,	10¾	10 9-16	10 3-16
Do. 6 per Cent. Preference	13¾,	14¼	14⅛	13¾
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	10⅞,	11⅛	11¼	11
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	5½,	5¾	5 15-16	5 9 16
Do. Preference	12½,	12¾	12¾	12⅝
Great Northern	13¼,	13¾	13⅝	13 7-16
Indo-European	34,	35	—	—
Reuter's	7,	7½	—	—
Submarine	190,	200	199½	198
West India and Panama	⅞,	1⅛	1	15-16
Do. 1st Preference	8¾,	9¼	9	8¾ xd.
Western Brazilian	7¼,	7¾	7½	7¼
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅝,	⅞	—	—
Oriental	3-16	5-16	—	—
United Telephone	13¾,	14¼	14⅛	13¾ xd.

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	3,	3½	3⅝	3½
Do. (fully paid)	4¾,	5¼	5	4¾
Swan	1⅜,	1⅝	1⅝	1⅜
Maxim Weston	5-16,	7-16	7-16	⅜

MISCELLANEOUS.

Telegraph Construction	39	40	39¾	39½
India Rubber, Gutta Percha, and Telegraph Works	24½	25½	24¾	24½

TRAFFIC RECEIPTS FOR NOVEMBER, 1886.

Companies.	Nov., 1886.	Nov., 1885.	Increase.	Decrease.
Cuba Submarine	2,550	2,313	237	—
Eastern Extension	36,729	40,427	—	3,683
Eastern Telegraph	50,817	56,245	—	5,428

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NOTES.

The Brussels International Exhibition of Telephony.—The date of the opening of this Exhibition has been fixed for the 9th January.

The West Coast of America Telegraph Company.—The gross earnings of this company for the month ending 30th November amounted to £4,190.

Direct Spanish Telegraph Company.—The estimated traffic receipts of this company for the month of November amounted to £1,860, against £2,030 in the corresponding period of last year.

Lighting of Railway Carriages in Germany.—The Administration of Railways in the State of Wurtemberg have decided to adopt electric lighting for all first and second class carriages upon their lines.

The Institution of Civil Engineers.—At the next ordinary meeting, Tuesday, December 14th, the discussion on the paper by Dr. John Hopkinson, F.R.S., on "The Electric Lighthouses of Macquarie and of Tino," will be continued.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending December 3rd were £3,688, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Rochester, N.Y.—The Telephone Company at Rochester, N.Y., having given notice of an intended revision of tariffs, whereby the rates for business houses would be largely increased in comparison with those for private residences, out of 700 subscribers 600 have given notice to terminate their contracts.

West Hanney Church.—The installation in the nave of this church, to which we made some reference last week, consists of ten 16 candle-power lamps, supplied with current from a primary battery of 8 large sized cells. The battery was supplied by the Electric Apparatus Company, and the expense was undertaken by the Rev. J. MacDougall, the vicar of the parish.

Chatham.—On Monday evening a party of gentlemen paid a visit to Chatham, with a view of inspecting the Thomson-Houston electrical installation erected there by Messrs. Laing, Wharton, and Down. The plant has been erected in Messrs. Scott's timber saw mill, and is sufficient to light 18 arc lamps, which are distributed in the streets and a few shops in the neighbourhood.

Brazilian Submarine Telegraph Company.—The directors of this company, on Wednesday, declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended September 30, 1886, payable on the 24th inst. The books of the company will be closed from the 17th to the 23rd inst. inclusive. The traffic receipts for the week ended 3rd instant amounted to £4,515.

Paris.—The Exhibition of the Sciences and Industrial Arts at the Palais de l'Industrie was closed upon the 7th inst. A large number of diplomas of honour have been awarded to the various exhibitors of electrical apparatus. The representatives of the Thomson-Houston Company obtained honours for arc lighting, Messrs. Woodhouse and Rawson for their incandescent lamps, and Messrs. Gaulard and Gibbs for their transformers.

Proposed Electric Telegraph Jubilee Exhibition.—We are informed that at the weekly meeting of the Council of the Balloon Society, held in the Library of the Royal Aquarium, Capt. Parry, R.N., in the chair, the following resolution was proposed by Mr. Rogers, C.E., seconded by Mr. Merritt, and carried unanimously:—"That an Electric Telegraph Jubilee Exhibition should be held to celebrate the invention of telegraphy in 1837."

Great Northern Telegraph Company.—We are advised that telegraphic communication with China, Hongkong, and Manila by this company's route is restored, and the line is again working well. The traffic returns for November were £21,200; and the receipts for the period from 1st January to 30th November, £239,000; for the corresponding months of 1885 and 1884, £264,440 and £257,480 respectively.

Lighting of a Corn Mill.—Messrs. Wilson Hartnell have recently placed an installation in a large corn mill at Leeds, a class of work which this firm makes a speciality. The number of lights at present in use is about 220, but provision is made for 450. A Crompton No. 15 compound-wound machine is used, and is driven by counter shafting from the mill engines. The dynamo switch-board is of slate, of Hartnell's patent type.

The International Cable Conference.—The meetings of this body which have stood adjourned since May last were resumed in Paris on the 7th inst., but owing to some of the signatory States not yet having given in their adhesion to Clause 12, the Conference has been again adjourned until July 1. The clause referred to provides for the investigation by a committee of the Conference of all laws which may from time to time be passed in any of the signatory States, and which may have any direct or indirect bearing upon submarine cables.

The Severe Gale.—A gale of exceptional severity passed over the United Kingdom on the 8th inst., and was accompanied in many districts by thunder and lightning. The church of St. Andrew, in Princes-street, Lambeth, was struck by lightning, and a large stone cross was precipitated into the roadway. Telegraph lines were blown down in all parts of the country, and it is long since such a general interruption of telegraphic communication has been experienced. At Brighton the Electric Railway, which suffered so severely in the gale of October 17th, has again received some damage, but not apparently of a serious character.

New York Tramways.—The Julien system of electric tramways, in which secondary batteries are employed, has been introduced into New York. A car is now running upon the Third Avenue line, and the system is attracting much attention. Hitherto very little has been done in America with secondary batteries for this particular purpose—and, indeed, comparatively little for any other purpose. It is stated that the Third Avenue Tramway Company has definitely decided to abandon horse traction in favour of some form either of mechanical or electric propulsion—probably the latter—but the particular system has not yet been finally selected. This company at present employs over 3,000 horses.

Visit to Messrs. R. E. Crompton's Works at Chelmsford.—The Mechanics' Institute of Chelmsford paid a visit last Wednesday to Messrs. R. E. Crompton and Co.'s electric light works. The visitors, who numbered about 400, were shown round the works and had the machinery and the different stages of manufacture explained to them by the pupils and staff. A search light was in operation in the tower on the roof of the works, from which a good view can be obtained of the surrounding country on all sides. A short popular lecture was given later on by Mr. Crompton, and afterwards a more

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detailed explanation by Mr. Swinburne. Refreshments were liberally supplied in the manager's house close by.

TELEGRAPH SCHOOLS IN AMERICA.—We subjoin the following paragraph from an article relating to American telegraph schools in one of our Transatlantic contemporaries:—"In the school alluded to the method pursued is what is called the 'g. b.' After a poor devil or deviless has pounded away for a specified length of time the 'lord high executioner' decides that he or she is a failure, and—pht-t-t, the individual disappears. If there are friends and backbones to make a fight, why, a compromise is effected, and part of the money is refunded, but generally the bitter pill of disappointment is swallowed, and the pupil looks up a half interest in some other fraud or disappears in the scum of the city's whirlpool."

LECTURE AT THE ARCHITECTURAL ASSOCIATION.—Mr. Maxmilian Clarke has been good enough to send us a copy of his paper on "Artificial Lighting," which was lately read before the "Advanced Class of Construction" of the above association. In referring to this in our last issue we attributed the paper, in mistake, to Mr. John Slater. Mr. Clarke's paper is one which we are sure must have proved of very great interest to his audience, and we are very glad to find that steps are being taken to bring the advantages and the methods of electric lighting prominently before the rising architects of the day. The rooms were lit by incandescent lamps provided with current from E.P.S. cells, which the company had kindly lent for the occasion.

THE BRIGHTON ELECTRIC LIGHT COMPANY.—At the annual meeting of the Brighton Electric Light Company, the chairman reported that the business of the company was increasing very satisfactorily, and that the directors had decided to double their engine and dynamo power, at an expenditure of £200. This extension of the plant would bring the lighting power of the station up to 2,000 incandescent lights. The mains of the company now extended over a distance of 11 miles. The chairman said he considered that the dividend of 4 per cent. on the first year's trading, after providing for depreciation of plant, &c., was an encouraging one, and he hoped to be able at the annual meeting next year to announce a large increase in this dividend. To provide for the extension of the company's plant, a call of £800 had been made upon the present shares of the company, making them fully paid, and a further issue, to the extent of £1,200, being part of the capital of the company, had been decided upon.

PENINSULAR AND ORIENTAL COMPANY.—Speaking, on Tuesday, at the annual meeting of the Peninsular and Oriental Steam Navigation Company, Mr. T. Sutherland, M.P., the chairman, in the course of his remarks, said:—In connection with this question (referring to the new contract for the conveyance of the India and China mails), I may mention a fact of some interest, perhaps more in a scientific than a commercial point of view, though it bears a very important influence in relation to ourselves commercially—namely, that we have been able to employ the electric light in passing our ships through the Suez Canal during a portion of the last six or eight months. That is an alteration in the mode of working our vessels which will greatly tend to reduce the period of transit hitherto necessary for passing through the Suez Canal, and it will enable us to give a special success to the canal as a mail route. It is a curious fact that we find it to be practically easier to pass our ships through the canal at night by means of the electric light than in the day time.

PROPOSAL FOR ELECTRIC LIGHTING OF TRAINS IN TUNNELS.—With regard to our remarks under this heading in last week's "Notes," a correspondent from Edinburgh sends us an account of an arrangement precisely similar to the one which we suggested, and which, by a somewhat singular coincidence received its first experimental trial upon the Glasgow Underground Railway a few days previously. A conductor has been laid down between the rails from Queen-street station to the College station, and a trailing collector is lowered or raised by the guard at will. The experiments proved thoroughly satisfactory, and it is probable the company will adopt it for permanent use. In such a case as this, where the total distance is not great, it is of course practicable to supply current from a single station to all the trains, and at each tunnel upon the system, and this is the method which is proposed to be used at Glasgow. But when it is desired to provide for the illumination of trains while passing through tunnels at considerable distance apart, the use of secondary batteries will evidently be the only practicable plan.

PRIVATE WIRES IN THE UNITED STATES.—A recent article in the *New York Herald* states that there are now no less than 150,000 miles of private wires in or converging upon New York alone, of which about two-thirds of the whole are maintained by the Western Union Company. These figures sound almost fabulous, but many of the lines are of great length; more than twenty go to Chicago (over 1,000 miles), while wires to Boston, Philadelphia, Washington, and other distant cities also account for a considerable portion of the mileage. The annual rate for a special wire between New York to Chicago is from £5,000 to £6,000 per annum. Most of these twenty lines are in the hands of the great grain speculators. In the summer immense numbers of private lines are required between New York and the great watering places, as Newport, Saratoga, and Long Branch. Naturally, however, the local lines between New York, Brooklyn, and the various suburbs are the most numerous. These wires are erected and maintained by the companies, but the operators are provided and paid by the subscribers themselves. Morse recorders are almost universally employed.

THE ELECTRIC LIGHT AT THE BRITISH MUSEUM.—We recently mentioned the fact that the electric light in the British Museum Reading Room had one evening been extinguished an hour or more before the usual time. We are very pleased to learn from *Industries* that this inconvenient circumstance did not arise, strictly speaking, from any breakdown of the machinery, but from the fact that the engineer in charge made the discovery that some evil-disposed person or persons (supposed to be an *employé* under notice of dismissal) had put some sand into one of the engine bearings. It was therefore thought necessary to send notice to the librarian that the light would be discontinued in ten minutes' time. Unfortunately it was not possible to collect the books and dismiss the readers in the time of grace allowed, and consequently there were still a large number of persons in the room when the lights went out. By the aid of a few lanterns, however, in the course of another quarter of an hour the room was cleared. We are assured that efficient steps have been taken to prevent a repetition of such a dastardly act, and the frequenters of the Reading Room can rest content that they will not again be subject to such annoyance.

LA SOCIÉTÉ INTERNATIONALE DES ELECTRICIENS.—It is scarcely possible to congratulate this society upon having attained so high a standard in respect of the papers which are read at its monthly meeting as its position and title might justly lead us to expect. For instance, of the two papers read at the November meeting, while one (to which we make further reference in another note) is decidedly interesting, and

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may possibly have some future importance, yet it is difficult for an English electrician to speak of the other without something approaching contempt. The title is not unpromising :— "Sur quelques inventions historiques peu connues." Under this head the society listened to a *very* brief description (accompanied by a diagram) of Dr. Hopkinson's "invention" of the characteristic curve which the author was good enough to commend as a really useful idea. The author also exhibited the outline diagram of a decidedly abortive dynamo, which it appears he discovered some years ago in the correspondence columns of *The Electrician.* We have also—and equally *apropos* of nothing—one of Page's motors, *Anno*, 1850, a machine not without interest in itself, and a further diagram of an arrangement for winding field-magnet coils in several sections, and putting one or more in circuit with a radial switch. No single remark of any technical or theoretical interest is discoverable throughout the effusion, and its only merit is its comparative brevity. But surely La Société Internationale des Electriciens, if it is to justify its existence at all, should be able to provide somewhat more substantial fare than this.

Conversazione at King's College.—The King's College Engineering Society held a very successful *conversazione* in the college buildings on Friday, 3rd inst. A very large and interesting collection of scientific apparatus was exhibited in the great hall, and in the various laboratories numerous experiments were performed. A working model of a telpherage line, constructed by Mr. W. P. Adams, a student of the college, attracted much attention. Among other electrical apparatus exhibited in action there was a very fine display of "vacuum" and "radiant matter" tubes; an inductive coil experiment to show the degree of vacuum in a glow lamp; Prof. Forbes' thermopile galvanometer (exhibited by Mr. F. H. Nalder); a collection of microscopes provided with minute glow lamps illuminating the stage (the current for these little lamps was supplied by a set of Clammond thermopiles); and an Immisch dynamo and motor. These last were to have been exhibited in action, the motor driving the dynamo and being itself supplied with current from a Crompton machine in the basement, but owing to the excessive demands made during the evening upon the gas engine which drives the Crompton, it was not deemed advisable to run the motor for any length of time. In the museum of King George III. the remarkable historical collection of scientific apparatus, of which the College is justly proud, was exhibited. Here were to be seen Daniell's original battery, the old five needle dial telegraph; electric machines of the last century, and many of Wheatstone's original experimental apparatus. We have confined our description to the electrical apparatus, though of course there was much else to look at, which, together with an organ recital in the chapel, and a concert in the great hall, ensured a thoroughly enjoyable evening to all present.

Another New Method of Reproducing Designs.—Under the title of "Effluviography" (given to it by the discoverer), we published last week a note upon the above subject. We have now a further account of a process which effects a similar object in a somewhat different manner. This is due to Dr. Boudet, of Paris, and was described at length at the November meeting of the Société Internationale des Electriciens. It will, however, be seen that although the learned doctor does not appear to have made any reference to the fact, his experiments, though decidedly interesting, are nothing more than a further development and amplification of the very ancient experiment known under the name of Franklin's portrait. The paper contains an account of numerous modifications; but the main idea is the same in all, namely, that a high tension discharge (either from a Rhumkorff coil, or preferably from a static machine) is caused to take place across the plates of a condenser between which the design is placed. The dielectric may either be an air space—in which case the design may consist in a cut, engraved, or embossed metallic surface—or it may be a sheet of cardboard, paper, wood, glass, or other insulator—in which case the design may also be cut or stamped, or even drawn in crayon upon its surface. In every case the reproduction appears upon that plate which is attached to the *positive* pole of the machine. By this method Dr. Boudet has succeeded in obtaining a large number of accurate reproductions from a single crayon drawing, all the minutest features of the original being well preserved. If a stencil-plate, say of cardboard, be placed between two sheets of glass backed by metal plates, after the discharge has been taken, no trace is at first apparent upon the glass; but if the surface be now breathed upon the design appears. It may be permanently fixed by exposure to the fumes of hydrofluoric acid. Cameos or intaglios, such as medals, coins, or seals, may best be reproduced by covering the surface with plumbago, or with almost any powder, whether conducting or non-conducting. If any part of the design is to be omitted it is sufficient to moisten it with the least trace of alcohol.

The "Lancet" on the Lighting of Railway Carriages. In an article upon this subject the *Lancet*, after pointing out the short-sighted policy of the railway companies in the matter of providing insufficient light in their carriages, proceeds as follows:—"Meanwhile there is higher ground that must be occupied. A very considerable amount of actual mischief is done by the long persistent refusal of railway companies to provide suitable means of lighting their carriages. This is a subject on which much has been written, but to very little purpose. The only possible explanation of the great neglect which has been shown in this particular respect is that chairmen and directors have not the courage to incur the needful expenditure. There is, of course, no sort of difficulty in the matter. If only the will existed, plenty of ways and means of attaining the object in view could be found. The Metropolitan and District Companies, not because they are more liberal than others, but because the line lying underground the carriages must needs be lighted, have shown how gas may be employed; and other companies have, by experiment at least, demonstrated how electric apparatus may be adapted to locomotive lighting purposes. It has also been made plain that either gas or the electric light can be economised by being placed under the control of one of the companies' officials, to be turned up when passing through tunnels by day or when it grows dark at night, and turned down again at pleasure. In short, there is no sort of excuse for the failure to provide a proper amount of light for both ordinary and extraordinary purposes. Our appeal must be to the public, and we would point out that the practice of reading in railway carriages, as for the most part at present lighted, is one that ought to be discontinued. The instances in which injury is inflicted upon persons with weak or irritable eyes are very numerous; and cases of cerebral irritation set up by habitual efforts to read in dimly-lighted carriages are of frequent occurrence. Until the cry for more light elicits a response, it will be simply prudent to abandon the attempt to beguile the time spent in railway journeys by reading. Better do this than sacrifice sight or induce brain disease."

Telegraph Clerks and the Royal Commission.—A meeting of the Plymouth telegraph staff was held at the Borough Arms on Saturday evening, for the purpose of electing a committee to decide as to the best steps to be taken for collecting evidence and statistics for the executive committee at Liverpool to lay before the Royal Commission at present

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inquiring into the working body of the Civil Service establishments. Gratitude was expressed for Mr. Fawcett's efforts on behalf of the clerks, but some of the defective points in his scheme were pointed out, one of which is that no less than fifteen years must elapse from the date of appointment as an efficient clerk (say eighteen years of age) before a salary of 38s. per week can be obtained; beyond this sum the salaries of the present junior staff cannot rise, judging from the ordinary rate of promotion. Moreover, the salary held to be comparatively fair at the start, viz., 16s. per week, is at 21 years of age only 20s. 6d. It was stated that in the telegraph department there were men with fifteen years' service who had not yet reached the maximum of their class (38s.), whereas in the Post Office clerks with sixteen years' service were in receipt of higher salaries than those with twenty-eight years' service in the Telegraph Department. It was also pointed out that no appointments as postmasters or to fill vacancies in the surveyor's or engineering departments, had taken place from the Plymouth telegraph office within the past 17 years, consequently the only promotions to the first class were caused through increase of work and a corresponding increase of staff. The following resolutions were passed unanimously:—"That the present system of promotion by selection irrespective of merit is strongly condemned." "That this meeting expresses satisfaction at the appointment of a Royal Commission to inquire into the working of the Civil Service, in the hope that it will ensure an examination into the cause of dissatisfaction existing amongst the telegraph clerks and the partial success of the telegraphs, and its especial thanks to Mr. Puleston, M.P., for obtaining the inclusion of the telegraph department within the scope of the inquiry." It was decided that a copy of this resolution be sent to Mr. Puleston, M.P.—*Western Morning News.*

THE CONDENSER ON TELEPHONE CIRCUITS—AN ERRONEOUS CONCLUSION.—In a note recently presented to the *Academie des Sciences*, M. Charles Cros describes some experiments on the use of a condenser in connection with telephone circuits. Having constructed an artificial line, consisting of coils of insulated wire, connected with a commutator, by which any required number of coils in series could be placed in or out of circuit, with a pair of telephones, the author added coils until the articulation of the receiving telephone could no longer be understood. He then inserted a condenser at the middle of the line, and found that the volume of sound was at once largely augmented. M. Cros proceeds to suggest the practical application of his discovery (?) upon long lines; and then theorises upon the subject with especial reference to the analogy between electric currents and fluid motion. He has further constructed an elaborate arrangement of pipes and closed chambers, whereby he obtains a mechanical analogue of the circuit in question. Without staying to examine this part of the research, it may be safely stated at once that M. Cros has entirely overlooked one most important factor, the neglect of which vitiates both his arguments and his deductions. M. Cros is dealing with alternating currents, yet he has left entirely out of sight the question of the coefficient of self-induction of the circuit. If the experiment is repeated under practical conditions – that is, upon a straight wire of sufficient length to prevent intelligible communication by virtue of its resistance pure and simple—it is tolerably certain that the introduction of a condenser would no longer have the effect described. In default of facilities for such an experiment, ordinary resistance coils, wound non-inductively, might be employed. This question of the employment of alternating currents upon open circuits containing both condensers and self-induction has been very fully investigated from the theoretical side by Mr. T. H. Blakesley, who in his book on "Alternating Currents" (page 47) writes:—"The result may be summed up in the following words: When an alternating generator operates upon a circuit which is closed by a condenser without leakage, and which possesses a coefficient of self-induction, then there is a certain period of alternation which may be given to the generator, at which the condenser might be replaced by a junction introducing no additional resistance into the circuit, *the coefficient of self-induction being also removed*, without disturbing the current." Although the conditions are somewhat modified when we employ a telephone transmitter in which the period of alternation is continually varying, yet it is easy to show that there will be a wide range for the value of the capacity of the condenser in relation to the coefficient of self-induction of the circuit, within which the general effect will be to enable communication to be effected through a larger number of coils such as those used by M. Cros.

THE SOCIETY FOR THE PROTECTION OF LIFE AND PROPERTY FROM LIGHTNING.—We have received from Mr. W. M'Gregor, M.S.T.E. (secretary of the above society *pro tem.*), a small pamphlet setting forth the objects and methods of this society. It is proposed to establish a central bureau, which, among other things, shall undertake the examination of architects' and builders' plans in reference to chimneys, steeples, and towers, the periodical inspection and testing of lightning conductors, the registration of persons properly qualified for the last-named duty, to bring about *esprit de corps* amongst architects, engineers, builders, and manufacturers of lightning conductors, and, lastly, "to advise and encourage Governments, officials, heads of departments, the clergy, churchwardens, local boards, and others whose duty it is to protect life and property to employ the means available." It cannot be denied that, however laudable may be the aims and intentions of this society, they have succeeded in setting them forth in a manner which will, we fear, do much to hinder their own usefulness, and, indeed, can best be characterised as "fussy." Architects and builders will scarcely be so ready to submit their plans for the criticism of a self-constituted body as the society seems to imagine. The society's certificate of qualification as to ability to test a lightning conductor, will not, we fear, be very eagerly competed for, and possibly "Governments, clergy, churchwardens, and others, may not always consent to receive advice and encouragement." It must not, however, be supposed that we entertain any hostility to the society itself, which, indeed, may prove very useful in awakening public attention to the importance of securing an adequate and efficient system of lightning conductors on all buildings of any height or importance. But after all we suspect that so long as the fire insurance companies do not move in the matter it will be a difficult and thankless task to stir other people. But, in addition to this practical business, the society proposes to organise a scientific section who are to undertake the investigation of the meteorological and other phenomena attendant upon lightning. They are more particularly to observe the geological features of districts in which thunderstorms are of frequent occurrence, likewise the physical characteristics of the surrounding country, and, further, in the department of biology observations are to be made upon the bodies of the slain. This is division B. Division C has as its object the discussion and enforcement of "means by which to educate public opinion to the pitch of demanding municipal or other inspection and control of lightning conductors." Lastly, division D undertakes the formation of a museum, library, and laboratory. Every member on payment of his entrance fee and subscription is entitled to have his house examined by the society's inspector.

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 75.)

In order to obtain a high degree of sensibility the wire must be wound very closely round the magnet. In Sir William Thomson's galvanometers there are generally three or four or more magnets made from watch spring and attached to the back of a small mirror of silvered glass, the axes of the magnets being all parallel, and their north poles pointing in the same direction. The mirror with its attached magnets is suspended by means of a single silk fibre within the circular coil, and the interior diameter of the coil just allows sufficient freedom for the mirror to swing.

In the dead beat galvanometer the mirror is placed in a brass tube which it nearly fits, and a brass or copper stop is fixed just behind it, while a plate of glass is fixed just in front, allowing the needle only just sufficient space to swing through the greatest angle required.

The resistance which the needle experiences in churning the air in this confined space, and through the currents which it induces in the metal tube and stop when swinging, produces such an amount of damping that the needle when set swinging comes almost immediately to rest.

In the marine galvanometer the needle is suspended by a fibre which is attached both at the top and bottom of the instrument, and thus exposed to considerable tension. This prevents the mirror from swinging like a pendulum. The variable action of the earth and the ship's magnetism, as the vessel swings, is obviated, according to the principles explained above, by enclosing the instrument in a wrought-iron case, leaving only a window open for the entrance and exit of a beam of light. The controlling magnet is placed within the iron case. The instrument is thus protected from the action of magnetic bodies outside it in the same way as electrical instruments are protected from the action of external electrified bodies when they are surrounded by closed conductors or wire cages.

In the mirror galvanometers, the deflection of the needle is observed by means of a beam of light from a lamp, which is reflected from the mirror, and falls on a graduated scale. The reflected ray turns through double the angle turned through by the mirror. The light from the lamp is usually allowed to pass through a hole in a screen, across which a vertical wire is stretched, and a convex lens is introduced in the path of the beam, which causes an image of the slit and wire to be formed upon the scale. By employing a very light mirror in a dead beat galvanometer telegraphic signalling may be read after passing through a submarine cable.

In the sensitive galvanometers above referred to the current is not strictly proportional to the tangent of the angle through which the mirror is deflected, for, as the needle turns, its poles get farther aware from the wire, and the force exerted upon them by the current is diminished. In order that the current may be strictly proportional to the tangent of the angle of deflection, the magnetic field produced by the current, as well as the permanent field within the instrument due to the earth and the controlling magnet (if there be one), must be constant throughout the space in which the needle moves. To secure this the controlling magnet is dispensed with, and the interior diameter of the coil made very large in comparison with the length of the needle. An instrument so constructed cannot be very sensitive. A galvanometer of this class is usually called a *tangent* galvanometer or *tangent compass.*

Helmholtz improved the tangent galvanometer by employing two equal coils placed parallel to one another, and having a common axis, the distance between the coils being equal to the radius of either. The needle is very short, and is suspended midway between the coils. As the needle swings, and its north pole recedes from one coil so that the force exerted upon it by the coil is diminished, the same pole will approach the other coil, whose action upon it will be correspondingly increased. The same will be true of the south pole, and thus the forces exerted by the current upon the poles of the magnet will not sensibly vary as the latter swings.

Fig. 5 shows the lines of force in Helmholtz's form of the instrument, and it will be noticed that for some distance near the centre the lines are practically parallel. The lines of force in each case are due only to the current in the coils of the instrument.

In the sine galvanometer the coil is capable of being turned about a vertical axis, and when the needle turns in obedience to the current the coil is turned after it by hand, until the coil is in the same plane with the magnetic axis of the needle, and the angle through which the needle and coil are turned is observed. It will be found that as the coil is made to follow the needle the deflection of the latter will increase, but if the current be not too great for the instrument, the coil will at length overtake the needle. The *sine* of the angle of deflection will then be proportional to the current, and since the needle is always in the plane of the coil when the deflection is observed, the length of the needle may be nearly equal to the internal diameter of the coil, for its poles are kept in the same positions relative to the wire.

When a current passes through a coil of wire, magnetic lines of force are found to encircle the wire, and all pass through the coil in the same direction. These lines of force may be regarded

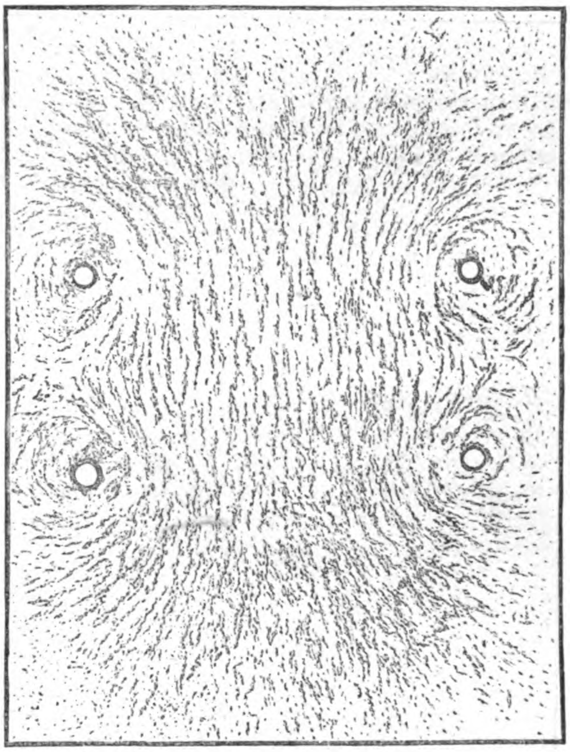

FIG. 5.

as proceeding outwards from one face of the coil, just as they proceed from the north pole of a magnet, and inwards towards the other face, as the lines of force converge towards the south pole of a magnet. Hence, as far as its action upon everything outside the coil is concerned, the coil of wire through which a current is flowing will behave like a plate of steel, having the same periphery as the coil, and magnetised so that one face consists wholly of a north pole, and the other face of a south pole. If a right-handed screw were rotating with the current, and carrying the coil with it in its motion, the face of the coil which is advancing would be the north pole, and that which is receding the south pole.

If two such magnetised discs of steel were free to move they would turn so that the south face of one disc is presented to the north face of the other, and would then attract each other. Fig. 5 shows the lines of force due to a pair of coils, in each of which the current is flowing in the same direction.

Hence, two coils conveying currents will, if free to move, turn so that the currents flow round each coil in the same direction, and will then attract one another, since the magnetic fields they produce, and on which their mutual action depends, are identical with those of the steel discs or "magnetic shells."

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If the steel discs were turned so that they presented similar poles to each other, they would repel one another. Similarly the two coils will repel one another if they are so placed that the currents in the two are in opposite directions, and the coils are prevented from turning round. The lines of force due to such a pair of coils are shown in Fig. 6.

Since the attraction or repulsion between the coils must be due to the actions of the several portions of the wires upon one another, it follows that wires which are conveying currents in the same direction attract one another, and wires conveying currents in opposite directions repel one another. This also admits of independent experimental proof.

If two wires are conveying currents in directions making an acute angle with one another, the wires will attract each other. If the directions of the currents form an obtuse angle, they will repel each other. If the wires are free to turn they will set themselves so that the currents are flowing in the same direction in each, and they will then attract one another.

It has been stated that the poles of a magnet will tend to rotate in opposite directions around a wire conveying a current. Similarly, a wire conveying a current will tend to rotate

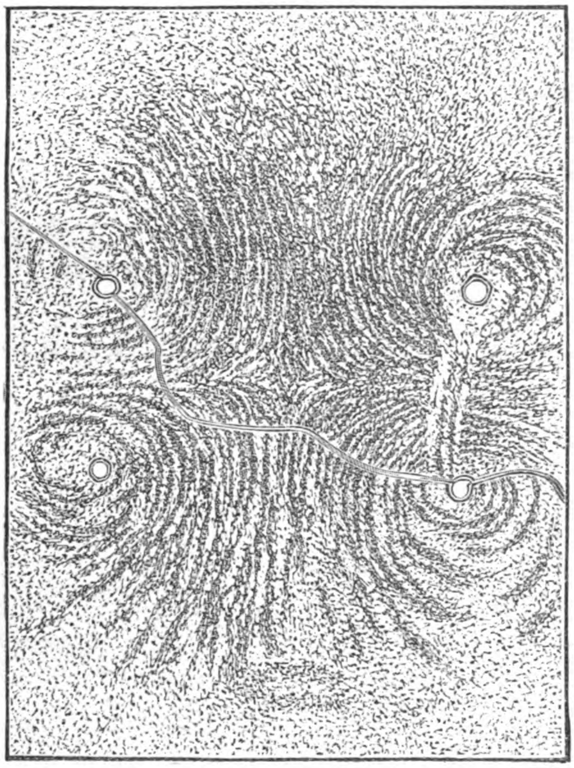

Fig. 6.

about either pole of a magnet, since action and reaction are equal and opposite. Faraday, in 1821, obtained the continuous rotation of a wire about a magnetic pole by sending a current through a wire which could turn about a joint at its upper extremity, while its lower dipped in a circular trough of mercury which surrounded the pole of a magnet. The rotation of a conductor conveying a current about magnetic lines of force can be readily shown by the following contrivance :— A beaker containing dilute sulphuric acid is placed upon one pole of an electro-magnet; a copper plate and zinc plate are connected by parallel wires, so that the zinc plate is vertically over the copper plate, and the arrangement is suspended by a thread within the acid, the copper being near the bottom and the zinc near the top of the liquid. A current flows through the liquid downwards from the zinc to the copper plate, and upwards through the connecting wires. On exciting the magnet the acid will rotate about a vertical axis in one direction, while the suspended plates and wires will rotate in the opposite direction. On reversing the polarity of the magnet the direction of each rotation will be reversed.

(To be continued.)

INCANDESCENT LAMP MANUFACTURE.—II.

BY J. SWINBURNE.

Retort Carbon.

The early workers in the field seem to have used retort carbon sawn into thin strips. The fault was, of course, that the carbons were not of uniform resistance, and the processes of manufacture were too difficult.

Coming down to modern times, we find Sawyer, or Sawyer and Man, decomposing hydro-carbons by heat, and utilising the deposited carbon. They used a thin piece of willow charcoal as nucleus, and deposited a thick coating on it by electrically heating it under such liquids as alcohol and olive oil. The carbon was used as so made, or the deposited carbon was removed from one side so as to expose the willow charcoal, and the charcoal was then scooped out, leaving a sort of crescent sectioned or boat-shaped conductor. This process is fully described in "Electric Lighting," by Sawyer (Nostrand and Spon, 1881), so there is little use in describing it here. Sawyer's lamp was at that time a very primitive apparatus, and his method of making carbons has never come into general use. However, as this has been, and may soon again become a matter of litigation, the point had better not be discussed here.

Carbon deposited by decomposition of such bodies as oil, alcohol, or hydro-carbon, seems to be almost a distinct allotropic modification of that element. Charcoal raised to a very high temperature acquires the same, or almost the same, properties, so these properties no doubt result from the high temperature, and not from the source of the carbon. Among these properties are high electrical and thermal conductivity, hardness, incombustibility below a very high temperature, and inability to occlude much gas.

Carbon deposited by decomposition of hydrocarbons seems always to be nodulous, even if deposited slowly at very high temperatures.

Jameson, of Newcastle, has worked at deposited carbon. His plan was to deposit it inside glazed porcelain tubes, and to turn the carbon conductors out of the resulting carbon tubes, like little piston rings. He abandoned these experiments either because they did not look promising or because his time was too fully occupied in working out his coke process.

If a gaseous hydrocarbon is rapidly decomposed by heat, the carbon is deposited in tufts of fine black hairs. Messrs. Hughes, Maxwell, Rowland, and Chambers have lately been working at deposited carbons. One of their methods is to make these carbon hairs artificially for use in incandescent lamps. These carbon hairs are sometimes produced in great quantities, and of great length, in coke ovens. Either Mr. Cookson or Mr. Jameson gave the writer a box of these carbon hairs to try as lamp carbons in the spring of 1883. Unfortunately, the hairs were too crooked and too uneven and unmanageable for use, and were not tried.

The Cruto lamp is made by heating a very fine platinum wire electrically in an atmosphere of some gaseous compound of carbon. The process is very interesting, but is somewhat difficult, as the platinum must be raised to a temperature very close to its melting-point in order to decompose the gas. The writer has no special experience of this kind of manufacture, so he cannot give any information beyond that already published on the subject. A short account of the manufacture of Cruto lamps has already appeared in the electrical papers. It has sometimes been said that the Cruto lamp is superior to others, because it has a hollow carbon. In the chapters on testing, and on the theory of the incandescent lamp, it will be shown that this reasoning is fallacious. The chief fault in this method of making carbons is that they are of such low specific resistance that a carbon has to be made very long and thin to give, say, fifteen or twenty candles at, say, 100 volts. This lamp, on the other hand, should be very well adapted for low resistance, or series work, as it is difficult to make a carbon by other methods which will take several amperes without being inconveniently thick. The Cruto carbons have a beautiful finish.

Messrs. Boullon, Probert, and Soward have made very thin carbons by a curious process. They pass induction coil sparks between two points in a hydro-carbon atmosphere. This decomposes the hydro-carbon, and builds up a very fine carbon

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thread. The electrodes are made to recede as the carbon is formed. Some short carbons prepared by this method were given to the writer by Mr. Probert. They were so exceedingly fine, however, that they could not be easily mounted. The extreme fineness also made them unsuitable for anything but lamps of very small candle-power, as it would have taken some feet to make an ordinary lamp, and such a length would not have supported its own weight.

The writer has tried some experiments with the view of depositing carbon on metal wires so as eventually to get rid of the metal, but without success. Fine iron wires were heated electrically in an atmosphere of carbon disulphide. When any part of the wire became red hot it was attacked so vigorously by the sulphur that it fused at that point. Of course, immediately the iron was partially converted into sulphide the resistance at the part attacked increased. The same thing happened when the experiment was tried in an imperfect vacuum. Even if the whole of the iron were converted into sulphide with carbon deposited throughout, there might be difficulty in getting rid by volatilisation or otherwise of the sulphide.

A similar experiment was tried with carbon tetrachloride instead of sulphide, but with no better results. The chlorides of most of the metals are volatile. It would be interesting to see whether carbons could be made by these means, a furnace being used instead of electrical heating.

A great many futile expriments will be described in these articles, because many who would otherwise have thought of the same things and tried them may be saved the trouble, and many may see the causes of the writer's failures, and may, by avoiding them, work out some of the ideas successfully.

Vegetable Carbon of Organic Structure.

Under this head are included carbons made of carbonised paper, bamboo, various grasses, roots, woods, &c., and cotton or linen thread.

There is no doubt that carbons consisting of bundles of partly separate fibres are weak, and that all the carbons in this group are inferior to some other carbons in use. Of course, many of the materials may be partly "parchmentised" or converted into an amorphous substance of the same percentage composition as cellulose, and the more nearly the carbon is made homogeneous the better.

Thin slips of bamboo are used by Edison even now; but the resulting lamps are generally run at a low temperature. These bamboo slips seem harder than most carbons of the sort. They are apparently cut out of bamboo by special tools, and they look as if the carbons had been "treated," or, as it is sometimes called, "flashed," very little.

Carbonised paper was one of the first things tried. Swan appears to have used it first, and Sawyer, Edison, Maxim, and others have followed. The best kind of paper to use is the toughest and densest that can be got. The resulting carbon has a very high specific resistance, and would therefore be useful for high resistance lamps, but unfortunately it is not durable. Maxim used paper which had been carbonised in the presence of a hydro-carbon, and "treated" afterwards. Many of these paper lamps were very durable, and were only slightly inferior to the best amyloid lamps. The methods of testing by which these conclusions were arrived at will be explained in the chapter on testing lamps.

The writer has tried impregnating paper and cotton thread with various things to fill up the pores, and thus make the carbons more solid and less fibrous. Many kinds of gum, several resins, dextrin, starch, &c., are of little or no use.

Very good results may be got by the use of the aniline dyes. Of these, fuchsine is perhaps the most convenient. Fuchsine is soluble in alcohol, but the solution is deceptive, as it is not so strong as it looks. The best solution is got by adding about 10 or 15 per cent. of aniline to the alcohol. Aniline dissolves fuchsine readily, but as it does not dry well, too much will prevent the solution from drying. Methylated spirits may be used instead of alcohol. The paper blanks are dipped in this solution and allowed to dry before carbonising. Lamps made with these carbons are very durable, and the process is very simple, and the carbons can be made by girls. Cotton thread steeped in this solution does not make good carbons. No one who has not tried it has any idea of the difficulty of cutting a lot of paper slips alike. It is absolutely necessary in the commercial manufacture of lamps that the finished carbons should all have the required surface. The Maxim carbons were beautifully cut into the form of an M. Paper cannot be cut uniformly by a bookbinder's knife, as it gives a little under the pressure. A sunken punch and a piece of lead are used for cutting out numbers or stars or such things, but it would be difficult or impossible to cut out a horseshoe groove three inches long and one-fiftieth of an inch broad in the face of a steel punch. Moreover, the blanks could not be got out whole. The converse method of punching the blank into the lead is good so far, but the blank sticks in the lead. The writer tried alloys of various kinds, with the view of floating the blank out by melting the alloy under oil; but the alloys that were sufficiently fusible were so hard that the material was injured in being punched into it.

A method often used is mounting the material on a cylinder in the lathe, and screw-cutting it into a spiral. This method has been patented by Messrs. Jackson, Davidson, and Duncan, and has also been used by other makers. The drawback is that it is slow and troublesome, and that it does not give a flat horseshoe, and the other form, in which the material is bent over into a loop, gives trouble in the processes following, such as mounting and carbonising. It is also more difficult to test this form accurately; the best method is stamping. This will be fully described under amyloid carbons.

Great caution must be observed in the use of aniline dyes. Some of them are very dangerous, as they give rise to blood-poisoning. Aniline itself is also to be handled with great care. Aniline dyes are very penetrating. If a girl is given a couple of ounces of fuchsine solution she gets it over her fingers, probably spills some, and gets it over her clothes and face, and everything she can possibly get at is eventually *couleur de rose.* A reducing agent, such as sodium sulphite, should be supplied to discharge the colour, as it is exceedingly difficult to wash out completely.

Various roots and fibres have been recommended or used; but though they may be more or less hard they are difficult to make all of the same size.

At first sight it might seem as if cotton thread or paper heavily treated would make good lamps. Many of the early Lane-Fox lamps seem to have been made in this way. This method does not give good results, as the deposited carbon is apparently nodulous, and full of minute cracks, and forms a sort of shell over a soft fibrous interior, instead of filling up the interstices and making the carbon solid.

CORRESPONDENCE.

NOTATION, SATURATION, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The arrangement of wires supposed by Mr. Bosanquet can only exist if all the layers are spirals wound in the same direction. In this case the last turn of each layer would have to be secured in some way before the wire is cut off and a new layer begun. When I first adopted iron wire for the core of my armatures, I was fully aware of the theoretical advantages which such an arrangement would present; but I have never attempted to carry it out in practice, on account of the great difficulties and the increased cost of manufacture which it would entail. As far as I know, all dynamo makers who use wire simply lay it on in a continuous length, and in right and left-handed spirals, until the proper depth of core is reached. As a natural consequence the turns must cross each other, and the distance between the centres of two wires is at the crossing equal to the diameter of the wire. It might, however, be supposed that before and after crossing the wires would arrange themselves in the triangular fashion sketched by your correspondent. Perhaps with great care and special appliances it might be possible to produce this. The wires of each layer would then lie for the greater part of the circumference in the grooves between the wires of the layer underneath, and would have to be brought sharp across once in each turn so as

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to fall into the next groove. At the crossing points there would be formed a ridge along the cylinder, which would throw its surface out of truth, and although it might be possible, with great care, to distribute the ridges of successive layers evenly round the circumference, such a system would entail more labour and loss of time than the extra amount of iron got into the armature would be worth; besides which I very much doubt whether an armature so constructed would run true and be balanced. As a matter of fact the wire is laid on by special winding lathes, which guide it rigidly in right and left-handed spirals, and if you inspect an armature at any stage during the winding you will notice that it presents no ridges, and that the spirals are all even. When finished, the armature is almost mathematically true and perfectly balanced. I think after this explanation Mr. Bosanquet will agree with me that the way I estimate the space filled by iron is correct.

I am not sure whether I quite understand the meaning of his remark regarding the "errors which would arise from the impossibility of securing any accurate geometrical arrangements, or of preventing changes of figure in the section of the wire due to the force used." If he alludes to the reduction of diameter consequent upon the strain in the wire during the process of winding, I would point out that this reduction is infinitesimal, and, moreover, has no influence on the accuracy of the calculation, since the diameter of the wire does not enter at all. If he alludes to any deformation of the coil due to the strain of winding, I think he pays a very poor compliment to the ability of the modern electrical engineer. Surely he must know that dynamos of the present day are not the gingerbread things, held together by tape, wood, and a little glue, which they were ten years ago, and that modern dynamo makers treat this machine in the same way as other engineers treat their work—that is to say, every part is designed with a due regard to the strains it will have to bear. If your correspondent will favour me with a visit I shall show him the gunmetal supporting cylinder on which the iron wire forming the core of the armature is wound, and he will then see that any error in the calculation of area, as far as it refers to a possible deformation, is absolutely excluded. The question of units was thrashed out at the Society of Telegraph-Engineers, and the matter now stands thus: Every scientist of note is opposed to my system of units, and some practical engineers besides myself use them. The society has given me a patient hearing on this question, and since I have had my say I do not think it necessary to refer again to the matter here.

In a letter following that of Mr. Bosanquet, the writer accuses me of attributing but "secondary importance to scientific research' undertaken for the mere sake of advancing knowledge." I need hardly say that nothing could be further from my thoughts. I, in common with every electrical engineer, know how very much we are indebted to the researches of men like Faraday and Clerk-Maxwell, whose discoveries form the basis of all our recent improvements. The question at issue, however, is not the discovery of new laws which may at a future date prove of practical utility, but simply the application of the laws already discovered to practical purposes at the present day; and my contention is that if a man wants to get the credit for such practical application he must present it to the world in a form ready for use by the practical engineer or electrician.—Yours, &c., GISBERT KAPP.

Wimbledon, December 8, 1886.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Considerable perturbation in the minds of not a few scientists seems to have been caused by the arbitrary system of magnetic measurement introduced by Mr. Kapp.

I fail to see either the difficulties which are supposed to be introduced, or any want of proper precedent for this new departure. Mr. Kapp's object is avowedly to facilitate matters in handling the figures, and by common consent 10^8 absolute units are taken to one volt for this very same purpose. Adopting Mr. Kapp's symbols the equation for the E.M.F. in the coils of the armature is, in absolute measure,

$$E a = Z . N t . n,$$

where Z is taken in absolute lines, and n stands for the number of revolutions per second. In order to diminish the numerical value of $E a$ we introduce the volt, and say

$$E a = Z . N t . n . 10^{-8},$$

or, taking M to equal the number of lines per *unit of area* of iron in the core, and a its cross section,

$$E a = 2 M a . N t . n . 10^{-8}.$$

Now, all that Mr. Kapp does further than this is to multiply n by 60, making it to mean revolutions per minute instead of per second, and then, finding the numerical value for M still inconveniently large, to multiply the factor 10^{-8} by 100, making it 10^{-6}, M being thereby numerically reduced to $\frac{1}{6000}$ part of its original value, the true value of the unit line, on the other hand, being increased by 6,000 times. As a matter of fact, and I speak from experience, the above measure is far more convenient for the use of practical men than the absolute measure, especially in dynamo design, and herein lies the value of all Mr. Kapp's work. A practical man himself, he gives us theory in such a guise that we can all make use of it, and whosoever may or may not have had prior notions of a similar character to those of Mr. Kapp on magnetic saturation, he alone has given to dynamo engineers, in a language they can understand, the means of assigning correct proportions to the several parts of the magnetic circuit.—Yours, &c., GUY C. FRICKER.

Battersea Foundry, Battersea, Dec. 4, 1886.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Bosanquet has fallen into a not uncommon error in supposing that "when wire is wound, the coils of each layer bed in the hollows of the layer below." This mistake was made some time ago at a meeting of the Telegraph-Engineers, when it was seriously proposed to lay a bare wire in the wasted space between the coils.

A moment's consideration shows that in winding a bar the layers are alternately right-handed and left-handed, and that during a part of a turn a wire will tend to lie in the hollow, and in another part it will ride on the top of the wires of the lower layer. As a matter of fact, the number of *layers* per inch of a given wire turns out in practice to be identical with the number of *turns* per inch when wound on a bar.

In armature winding, when there is more than one layer, it is obvious that the wires cannot lie as Mr. Bosanquet imagines, unless there are an equal number of turns in each layer, the practice generally being to get in as many turns as possible, so that each layer may be full.

Mr. Kapp, as a dynamo maker, is, of course, fully aware of this.—Yours, &c., ALEXANDER P. TROTTER.

Bull Green Works, Halifax, Dec. 7, 1886.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is curious that after my letter of last week I should myself have to apologise for a clerical error in a paper of mine, due to mixed units. In paragraph 3 of my paper on "The Tension of Lines of Force," reprinted from the *Phil. Mag.* in your last issue, page 83, the magnets are said to be each ·526 centimetre in diameter. This should be ·526in. The calculations are all right, but the clerical error crept into the description. We measure such diameters with an English watch maker's gauge, and our form of reduction provides for the computation in centimetres. But we measure greater lengths direct from a metre scale, using in each case such instrument as is most convenient. This is an excellent illustration of the liability to mistake involved in the use of mixed units, although the mistake is not of great importance.—Yours, &c.,

R. H. M. BOSANQUET.

St. John's College, Oxford, Dec. 6, 1886.

DYNAMO TESTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In his article on "Testing Dynamo Machines," published in your issue of December 3, Mr. Swinburne, referring

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to the recent tests of the efficiency of the Edison-Hopkinson dynamo, says :—

"The power supplied to the two machines separately excited at no load is, according to *The Electrician* for March 12, 1886, 7·169 horse-power, or 5,350 watts, say 2,675 per machine. We thus have for the generator :—

Stray power	2,675
Loss in armature	1,360
Loss in magnets	716
Total loss	4,751
Output	40,600
Power supplied by belt	45,351

Commercial efficiency 88·2 per cent.

"This determination does not agree with those of Drs. Hopkinson. They make out the commercial efficiency of the dynamo to be 93·23 per cent. Unfortunately the published tests of Drs. Hopkinson discrepe too much to be of use. The power spent on turning the armatures with no currents is given as 7·169 horse-power, and when the full current is taken it apparently drops down to 2·22. The 93·23 per cent. is calculated from the latter figure ; but what becomes of the odd, the very odd five horse-power ?"

In these remarks Mr. Swinburne, not understanding the significance of the figures he has quoted, has fallen into grave error, which, though obvious, calls for correction, especially as it is the repetition of a mistake made by Mr. Kapp in dealing with the same figures in his article in the *Engineer*, March 5, 1886, which was corrected in the subsequent issue of the same paper, the correction having apparently escaped Mr. Swinburne's attention. Mr. Swinburne has assumed that the zero of the dynamometer scale employed was the point at which the index would stand when the machine was at rest. Such, however, was not the case, as the scale was placed arbitrarily, and all experiments made by taking the difference of two readings, the one when the machines were working with a known load and at a known speed, and the other when the machines were running at the same speed without load and with the magnets unexcited. The dynamometer reading first given is, therefore, the zero of the dynamometer scale, neglecting the friction of bearings and bending the belt, which was determined by separate experiment subsequently described at length in the same article. Thus, the odd 5 horse-power exists only in Mr. Swinburne's imagination. If Mr. Swinburne will refer to the actual figures published by Dr. Jno. Hopkinson and myself (*Philosophical Transactions* of the Royal Society, Part I., 1886), instead of referring to an unsigned article, for which we were not responsible, he will more clearly see that the mistake is his and not ours, and that our figures are perfectly accordant and precise within ¼ per cent., and prove beyond all cavil a commercial efficiency of over 93 per cent. exclusive of friction, and 91·9 per cent. when the mechanical loss, not only of the friction of the bearings, but also the loss by bending the belt round the dynamo pulley and the pulleys of the dynamometer, is included.

Nor is a matter of nearly 4 per cent. in efficiency a point of small consequence, for it represents in a dynamo of this size about 2¼ horse-power, which may be valued at £22. 10s. per annum, and therefore, reckoning 10 per cent. depreciation and 5 per cent. interest, such a dynamo of 91·9 per cent. efficiency is worth to the purchaser £150 more than one of 88 per cent. efficiency.—Yours, &c., EDWARD HOPKINSON.

Salford Ironworks, Dec. 6, 1886.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following extension of my method of testing dynamo machines will, I believe, be found applicable to well designed machines, in which the distortion of field by the armature current is small. The two machines are connected by a belt or otherwise, field-magnets separately excited, speed kept at what it is intended to work the machines subsequently :—

1st. Both machines excited, no current taken from generator. Let W_1 be power supplied to motor, w_1 power absorbed in heating armature conductor.

2nd. Generator unexcited. Let W_2 be power supplied to motor, w_2 power absorbed in heating armature conductor.

3rd. Generator excited and supplying current. Let W_3 be power supplied to motor, w_3 power absorbed in heating armature conductor, W_4 power given out by generator, w_4 power absorbed in heating its armature conductor.

4th. Reverse the machines, making motor generator, and generator motor, and take similar tests. Let W_1^1, w_1^1, &c., be the results.

5th. Run each machine singly as a motor. Let W_5 and W_5^1 be the power applied, w_5 and w_5^1 that absorbed in heating armature. At this speed and strength of field let U be the loss by undirected electrical energy in machine 1, U^1 in machine 2 ; F and F^1 be the respective losses by friction, air-pumping, &c. ; B the loss absorbed by belt.

Then we have

(1) $W_5 - w_5 = U + F$,

(2) $W_5^1 - w_5^1 = U^1 + F^1$,

(3) $W_2 - w_2 = U + F + F^1 + B$,

(4) $W_2^1 - w_2^1 = U^1 + F + F^1 + B$,

(5) $W_1 - w_1 = U + U^1 + F + F^1 + B = W_1^1 - w_1^1$,

(6) $W_3 - w_3 = W_4 + w_4 + U + U^1 + F + F^1 + B$,

(7) $W_3^1 - w_3^1 = W_4^1 + w_4^1 + U + U^1 + F + F^1 + B$.

From these equations all the factors may be determined with many checks. Should the values of $U_1U_1^1$ and $(F + F^1 + B)$ found from equations (3) (4) and (5) be found to suit equations (6) and (7), U and U^1 may be taken as constants for any load.

This is what Mr. Swinburne proposes in your last week's issue.

With some machines, at any rate, this does not appear to be the case, as, indeed, might be anticipated, and in this case by varying the load on the generator the approximate law of variation of U and U^1 can be determined. The efficiency, either absolute or commercial, for any load on the machine can then be calculated.

I have applied this method to several machines, and have been surprised at the closeness of the results.

It is absolutely necessary that the speed and adjustment of brushes be closely attended to.

The inefficiency caused by a wrong adjustment of brushes is hardly, I think, realised, or the fact that the absolute efficiency of a good machine certainly increases as the load on it is increased.

I do not agree with Mr. Swinburne in his preference for high-speed machines, but will not enter upon this question now.—Yours, &c., P. CARDEW.

Chatham, 8th Dec., 1886.

WELDING BY ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : We notice in your issue of the 3rd that Mr. Radcliffe Ward claims priority in welding by electricty in the year 1884. We beg to say we have used this method since 1881 for welding or soldering the lead connections on secondary batteries ; and prefer it to any other way, and doubtless other secondary battery makers have done the same. It makes a clean joint and good contact; little skill is required in manipulation.—Yours, &c., H. THAME AND CO.

3, Winders-road, Battersea, London, S.W.,
December 8, 1886.

[CORRESPONDENCE *continued on page* 103.]

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended the 30th November, are £2,229, as compared with £2,165 in the corresponding period of 1885. The August receipts, estimated at £3,633, realised £3,679.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 93
Elementary Electricity and Magnetism—II. (Continued.) Illustrated ... 97
Incandescent Lamp Manufacture.—II. By J. Swinburne 98
Correspondence ... 99 and 103
TELEPHONY ... 102
THE SOCIETY OF TELEGRAPH-ENGINEERS & ELECTRICIANS' PRESIDENTIAL ELECTION ... 102
Literature ... 104
On the Employment of Alternating Currents for Measuring Liquid Resistances. By MM. Bouty and Fossereau ... 105
On Mechanical and Thermal Effects accompanying Electrolysis. By M. Bouty ... 105
Contribution to our Knowledge of the Action of Electrolysis on an Electrolyte (Behaviour of Jelly). By Svant Arrhenius 105
Contemporary Progress. (Continued.) Illustrated ... 107
Dynamo Design ... 110
Clausius on Electricity and its Relation to Heat ... 110
Society of Telegraph-Engineers 110
Dynamo Characteristics. Illus. 111
Glow Lamps, their Use and Manufacture. By Major-Gen. C. E. Webber, R.E, C.B. ... 112
The Institution of Civil Engineers ... 113
Legal Intelligence ... 114
New Company ... 114
Companies' Share List ... 114

TELEPHONY.

English technical publications are often searched in vain for indications of progress in certain branches of applied electricity. So far as this country is concerned, progress seems limited to apparatus connected with electric lighting. We use the term seems advisedly, because we can hardly imagine that improvement is really wanting, but attribute the general ignorance of such improvements to the peculiar position which telegraphy and telephony hold here. That the telegraphic system of England is superior to that of any other country is a fact we readily admit, but we maintain that the public, who really support the system, would like occasionally to be taken more into the confidence of the authorities. They would like to hear of some of the marvellous deeds that are constantly being done, instead of waiting for the next great debate. What, for example, constitutes the ordinary number of words transmitted for newspapers in a day throughout the whole country? A cable is laid here or repaired there; but it is only by accident that this work is mentioned outside official reports. The American and other technical journals from time to time record improvements in telegraphic apparatus, while in England the improvements are made without any such record. The service is benefited all the same whether published or not; but a greater interest is taken in the work, and less soreness felt among inventors and their friends if publicity be given to these improvements.

When we consider the position of telephony in England the case is altogether different. Day by day the capital account is increasing, day by day the public is finding out what a great convenience a good system of telephony is, and yet in regard to improvements English telephony is as silent as the grave. We ask with all due humility whether the system is perfect? Turn to the *Transactions* of the Society of Telegraph-Engineers and attempt to find information on telephony. The attempt is in vain. Year after year goes by, and the *Transactions* contain no indication that there exists a branch of applied electricity of increasing importance, and in which so large a capital is employed. Once, we believe, the magnates of the telephone world opened their hearts and invited various gentlemen to see the working of a new piece of apparatus "brought from America.' We ask these magnates what they have done to foster improvements by their own staff? We ask the members of the staff of the largest company if almost every suggested improvement has not been pooh-poohed, and, further, is it not a fact that those members of the staff who show signs of interest in their work, and a desire to perfect details, are sooner or later found "seeking a situation?"

The users of the telephone complain of its imperfections, thus showing that the system is imperfect, and yet no one seems to have any practical interest in improving it. So far as we know, more has been done by the smaller companies than by the United Company. In the North many towns are being rapidly connected by trunk lines, and again is this the case in the West. Soon Bristol will talk with Cardiff, and in Lancashire all Cottonopolis will be connected; and so in other districts, such as around Birmingham and Leeds. Surely, we may ask if among all those persons connected with telephony there is not one who dares stand up before the Telegraph-Engineers and give an account of the work? We might suggest as a valuable contribution to the literature of telephony a paper on "The Faults as Reported in London in One Month." Much, very much, may be learned from failures, and above all from the failures during the infancy of a business.

Perhaps those who have read these desultory remarks thus far will have come to the conclusion that we are writing more for ourselves than for the general members of the profession. To this we reply that up to the present time we have given more practical telephonic information than any other publication whatever, whether in the form of a book or periodical—that we could probably give quite a startling paper upon the subject suggested, but it would not be from information supplied by the companies. Our intention is to hint that valuable information might be given by themselves rather than obtained from indirect sources. It seems to us, also, that the Society of Telegraph-Engineers should bestir itself from time to time to get papers of a technical character which would enlighten us somewhat upon the question of "progress in telephony."

THE SOCIETY OF TELEGRAPH-ENGINEERS. PRESIDENTIAL ELECTION.

The Annual Election of the officers of this Society took place last evening, with results the particulars of which are given below. Since our last week's issue ample evidence has reached us justifying the course we have pursued with regard to this Election. Our correspondence columns testify to the feeling aroused among a large section of the London members by the conduct of the Council, a feeling which has become more widespread in consequence of the course which some friend or friends of the Council's nominee for the presidential chair have seen fit to take in supporting him. A biographical puff of the true elec-

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tioneering type had been sent round to the electors, and carried to all appearance the *imprimatur* of the Society. We did not for a moment believe that it emanated from that source; but we cannot help regarding it as confirming our view that the Council itself was to the very last divided on the main question. Had it been otherwise there would have been no apprehension as to the security of the Council's nominee, and this remarkable document would not have been issued on his behalf.

Turning to the business of the evening, we have first to observe that the cheers which greeted Mr. Almack's question, and the still heartier applause which followed the President's answer, sufficiently indicated the feeling of the members with reference to the indignity put upon them by the issue of the document above referred to. The Council, as such, had nothing to do with its publication; and several of the Council members present declared they had not even seen it. We need hardly remark, however, that the ill-advised action of the candidate's friends would not of itself have elicited this manifestation of disapproval. Evidently a considerable number of the members present had made up their minds to a certain line of action, and resented the attempt to influence a decision already arrived at. Nothing, short of an adverse vote, could have demonstrated more conclusively the fact that, whether right or wrong in the recommendations we have made in this journal, we have had a considerable following of sympathisers.

But this is a trifle compared with the incident which followed. The voting papers having been deposited in the box, the scrutineers took charge of it, and retired at the usual hour—half-past eight o'clock. Usually on these occasions their work is done in a little over an hour; but although the scrutineers had been doubled in number, ten o'clock struck, half-past ten, and still they did not appear. Speaker after speaker followed each other, in order to fill up the time, discussing at extreme length questions which, although sufficiently interesting of themselves were not what the meeting was waiting to hear. Only at twenty minutes to eleven was the result made known. It was suggested, as an explanation of this unprecedented delay, that the list of alternative names to be selected from was longer than on previous occasions. We leave it to our readers to judge whether this circumstance alone afforded the true explanation.

The following is the list of officers elected:—

President:
Sir Charles T. Bright, M.Inst.C.E.

Vice-Presidents:

Edward Graves	J. Hopkinson, M.A., D.Sc., F.R.S.
Colonel Sir Francis Bolton.	William Crookes, F.R.S.

Ordinary Members of Council:

William T. Ansell, F.R.G.S.	Alexander Siemens.
Prof. W. E. Ayrton, F.R.S.	Augustus Stroh.
E. B. Bright, M.Inst.C.E.	Major Charles F. C. Beresford, R.E.
R. E Crompton, M.Inst.C.E.	Dr. J. H. Gladstone, F.R.S.
J. A. Fleming, M.A., D.Sc.	H. R. Kempe, A.M.Inst.C.E.
Prof. G. Forbes, M.A., F.R.S.E.	Sir David Salomons, Bart, M.A.

Associate Members of Council:
J. Brockie. Colin Brodie. C. H. B. Patey, C.B.

Honorary Treasurer:
Edward Graves.

Hon. Secretary:
Colonel Sir Francis Bolton.

Hon. Auditors:
W. Blundell. | F. C. Danvers.

Hon. Solicitors:
Messrs. Wilson, Bristowe, and Carpmael.

South of England Telephone Company.—The letters of allotment for the new issue of 10,000 Preference Shares in this Company were posted yesterday.

ELECTIONEERING AND SCIENTIFIC SOCIETIES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Since noticing your announcement of the forthcoming meeting of the Society of Electricians on Thursday next, and receiving from the secretary a ballot paper as usual, I have received with reference to the ballot an anonymous puff of the president-elect.

I write this to ask you to use your influence to prevent further disgrace to our hitherto respectable society by the recurrence of any such undignified proceeding.

It is also an insult to the president-elect and to the electors to suppose that his deeds are not household words amongst us and his genial presence a familiar reality.—Yours, &c.,

Edward Almack.

Fawley, Mount Nod-road, Streatham, Dec. 6th, 1886.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In reference to your leader of the week before last I think that the thanks of all the members of the S. T. E. are due to you for it.

Prof. Forbes's eulogy on the council candidate will no doubt have had much weight with those members who, living in the country, are unable to attend the society's meetings. Such members can generally only blindly follow the recommendations of the council, or at most judge by the work which their nominees have done.

Those members, however, who are in the habit of constantly attending the meetings have the evidence of their eyes and ears to go by as to the suitability of any candidates for office. I have the pleasure of knowing a considerable number of these London members, who are engaged in all branches of electrical work, and have spoken to some twenty or thirty of them on the subject. With only one exception (a friend who rarely attends, and had returned his paper without alteration) they are all voting for the candidate suggested by *The Electrician*.—Yours, &c., Unus pro Permultis.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Having travelled a good deal lately, and my papers having been pretty heavily handicapped, your July 23 did not come up to me till to-day, when I saw the "Cuttriss Patent Siphon Vibrator" article. With some surprise I read that the principal part of the *invention* is the adjustable vibrator at the right of the illustration.

In the early part of May, 1885, I made bold to send to the Society of Telegraph-Engineers a paper on a mode of increasing the speed and definition of signals with Sir Wm. Thomson's permanent magnetic recorder, which was printed in pamphlet form by them. At this time my siphon vibrator had had 10 months' continuous trial, and was, I have good reason to believe, the first in operation, and considerably added to the speed of the line it was used on.

Mr. Cuttriss may not be aware of this; in fact, the refreshing innocence with which the "Inventor" heralds the right hand part of the illustration would naturally lead some people to believe him to be the father of it; but

"Mony a man rocks anither man's bairn," &c,

In its adaption to the mouse-mill type of recorder Mr. Cuttriss has gone out of the way considerably to attain his end, making the alterations much more costly than necessary; and on a line where really delicate adjustment is needed would undoubtedly show to disadvantage.

There are many ways of obtaining the same end with the *assistance of a vibrator*; but I really think Messrs. Cuttriss, Dickenson, and other adapters should be satisfied with that part of their illustrations which strictly belongs to them.

Apologising for taking up so much space.—Yours, &c.,

G. F. Pescod.

San Juan del Sur, October 18th, 1886.

Mode of Increasing the Speed and Definition of Signals with Thomson's Permanent Magnet Siphon Recorder.

Thinking it might be of interest to some of the members of your society, I beg to send you the following account of a simple and very satisfactory arrangement for increasing the

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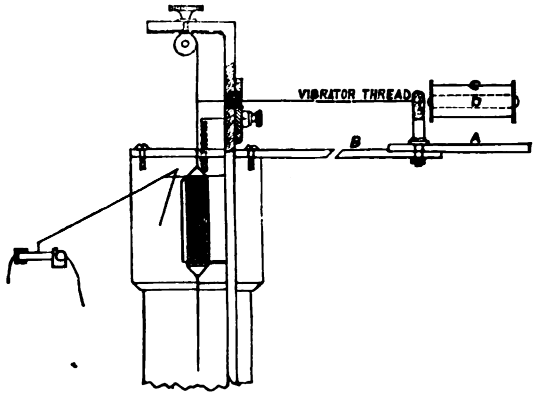
speed and definition of signals, with Sir W. Thomson's permanent magnet recorders, without electrification of the ink:—These recorders are admirable and economical for lines of 800 to 1,000 miles, but after that the friction between the siphon and paper begins to tell very much on the clearness of the signals. We have succeeded in reducing the friction to a minimum by vibrating the siphon very quickly, using a small make and break similar to that generally employed on induction coils. As will be known, in these instruments the siphon is rigidly fixed to the suspended signal coil; therefore, to obtain vibration of the siphon, the whole suspension must vibrate. This is obtained by leading a fibre from the hammer of the make and break to the thread supporting the signal coil, and fastened to it about half an inch from the top. On the battery being applied, and the right tension given to the threads, the action is found to lift the siphon rapidly up and down, and the same fine line is obtained as in the mouse-mill recorders. The paper is adjusted so that when the vibrator is working the siphon is from one-sixteenth to one-eighth of an inch clear from the paper; the vibrator, being placed a foot from the magnets, is not affected by it, and can be cut off and started at will. The arrangement is placed at the back of the instrument, a hole being drilled in the centre-piece to pass the vibrator thread to the suspension thread.



A Movable in the same line as thin board B. C and D also same direction.

To regulate, slacken vibrator thread by moving A towards magnets, then slowly reverse movement, drawing vibrator away from magnet till siphon vibrates steadily up and down. Care must be taken to have the signal coil quite clear from the magnets on both sides, or the line will be blurred when vibrating the coil, owing to its not having sufficient room. Should the vibrator not start well, it will most likely be found influenced by the large magnet, and should be placed a little further off. It is necessary to use condenser to prevent sparking at contact. The best siphons are long fine ones with only two bends.

It has been in operation on the longest section of the Central and South American Telegraph Company, from San Juan del Sur to Santa Elena, in Ecuador, nearly 1,600 miles, for eight or nine months, with excellent results, seldom requiring adjustment, and from the appearance of the signals, it could not be told that the coil was under vibration. The line of ink is perfectly even; it also has the advantage of permitting the use of much finer siphons than under the usual mode.

Not having heard or read of anything being done in this direction previously, I trust my experiment may be something new.

San Juan del Sur, Nicaragua, May 7th, 1885.

ERRATA.—In the report of the Physical Society's meeting on Nov. 27 in our last issue:—

Line	23	for	y	*read*	q
,	24	,,	q	,,	y
,,	27	,,	$-M\frac{dy}{dt}$	,,	$-M\frac{d\gamma}{dt}$
,,	31	,,	$p\int_0^{-0} x\,dt - My = 0$	,,	$p\int_0^{\infty} x\,dt - M\gamma = 0$
,,	32		$\int_0^{-0} x\,dt$	,,	$\int_0^{\infty} x\,dt$
		,,	Cyr	,,	$c\gamma r$
,,	20 from end	for	$K = \sqrt{a^2 \beta^2}/a$	,,	$k = \sqrt{a^2 - \beta^2}/a$
,,	18	,	,, ,, K	,,	k

LITERATURE.

Theory of Magnetic Measurements, with an Appendix on the Method of Least Squares, by F. NIPHER, A.M., Professor of Physics in Washington University. [Van Nostrand, 1886.]

This book is intended by the author to be a guide in the "practical details of a magnetic survey," and as far as this limited range is concerned it admirably fulfils its object. The mathematical work is simplified by making the usual assumptions which enable the higher analysis to be dispensed with, and when this method is impossible the results only of the more abstruse investigations are given. Thus, in discussing the "pendulum law," the assumption is made that the arc of vibration is infinitely small, and the periodic time is neatly deduced in an elementary manner; but in correcting actual vibrations to this ideal case the formula of reduction is given without proof. Specimen tables, worked out in detail, illustrate the more important computations necessary for reducing the observations; but we regret to notice that the foot-grain-second system of units is used. Surely it is quite time that the C.-G.-S. system should be universally adopted for the highly scientific work of a magnetic survey. The magnetometer figured (apparently taken from a trade catalogue) is less convenient than the Kew pattern, as there is no arrangement for determining the astronomical meridian, thus necessitating the use of a separate transit instrument. The appendix on the method of least squares will be found useful to those who are unable to consult more ambitious works on the subject; for ordinary work, however, we much prefer graphical methods for smoothing out the observational errors.

As we have already said, this volume treats its limited subject well, but we must strongly protest against the increasing practice, which it exemplifies, of setting forth on the title-page much more than is included in the subject matter of a book, and thus, no doubt unintentionally, misleading purchasers or library readers. The work before us is *not* an exposition of the "Theory of Magnetic Measurements" in the sense in which modern electricians understand the term. There is absolutely no mention of the measurement of intense magnetic fields, of the magnetic quality of iron, or of numerous other measurements which are of such importance to the workers of to-day. True, the first paragraph of the preface corrects the error, but as publishers seldom, and librarians never, include extracts from prefaces in their catalogues, the adoption, whenever possible, of correct titles would lead to much saving of valuable time and cause less irritation to the hard-pressed worker. In this instance the "Theory of Magnetic Surveys" would be such a title.

Lives of the Electricians: Profs. Tyndall, Wheatstone, and Morse. First series, by WILLIAM T. JEANS. [London: Whitaker and Co.; and George Bell and Sons, 1887.]

Our first thought on looking at the names in this opening series was that the selection hardly represented the electricians; but after glancing through the life of Tyndall we felt that on no account should it have been left out—rather, perhaps, that the title of the book might be changed to accord more closely with its contents. Reid's memoirs, published in America in 1879, entitled "The Telegraph in America, and Morse Memorial," deals very largely with the life of Prof. Morse, and is, perhaps, the best known book of its kind; but it is written more for American than for English readers, and will very well bear being supplemented by such a biography of Morse as we find in these pages. Of Wheatstone no adequate notice in this form has previously appeared; and there is a natural fitness in bringing the two great telegraphic personalities into juxtaposition within one and the same volume. Motives of a different kind have no doubt caused the name of Tyndall to appear first on the list of this series. He is an eminent man of science, who has gained the popular ear, partly, at least, by his public lectures on electricity. As a rule there are some obvious objections to writing the biographies of men still living, but no exception can be taken to Mr. Jeans' work on the score of excessive adulation. The

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narrative is a plain statement of facts, which of themselves are the highest tribute the author could pay to the subject of his memoir. Prof. Tyndall's career is sketched from his childhood down to his retirement from the position of scientific adviser to the Trinity House Brethren in 1883. Quite apart from his connection with electrical matters—which does not date very far back—Prof. Tyndall's life is a most instructive and interesting one, being that of a self-made man, who has attained to the highest distinction not only in the field of science, but as a master in the province of letters. An appreciative account of the late Prof. Wheatstone follows, and is of especial interest just now when the jubilee year of the electric telegraph is impending, and the question of its invention is one that is sure to be much discussed. Mr. Jeans settles this disputed point in favour of his hero, as was to be expected; but we cannot complain of his partiality, seeing that the fresh evidence he adduces on disputed points of history in this relation certainly makes for his view of the case. Whatever his merits as an electrician, Wheatstone was, without doubt, one of the most ingenious mechanicians that ever lived, and his name for all time will be associated with the introduction and practical development of electro-telegraphy. America had its Wheatstone, too, in Prof. Morse, whose name is closely identified with the earliest telegraphs in that country. The struggles and disappointments of this talented electrician are well described in these pages, and ought to serve as a permanent lesson of encouragement to every despairing inventor. We could have wished that Mr. Jeans were a little more liberal with his dates, so that any reader using the volume as a book of reference might know exactly where he is, or more correctly *when* he is; but in other respects these memoirs are carefully compiled, and, what is of equal importance in these days, attractively written. Merely as a book to read, "Lives of the Electricians" will amply repay the outlay upon it, both of time and money.

We feel it necessary, however, to mention that there are in this work several technical blunders, which would have been avoided or corrected had it been written by a professed electrician. Perhaps the worst of these is on page 130, where a cup of mercury is described as "a non-conductor." This is probably a typographical error; but not so the mistake which occurs in the descriptions of the experimental demonstration of Faraday's discovery of the electro-magnetic rotation of the plane of polarisation, and others of a similar kind.

BRITISH ASSOCIATION, 1886.

The following papers marked * were contributed to the late meeting of the British Association on various subjects connected with Electrolysis.

ON THE EMPLOYMENT OF ALTERNATING CURRENTS FOR MEASURING LIQUID RESISTANCES.*

BY MM. BOUTY AND FOUSSEREAU.

The authors criticise the employment of alternating currents employed by Kohlrausch and many others in the hope of diminishing the effect of polarisation. They point out that self-induction in the resistance box is fatal to silence in the telephone [naturally], and only succeeded in getting good results when they replace wire in their bridge by liquid resistances, describing for this purpose a libuid rheostat. Even thus, however, they hardly get concordant results when they try to apply the method to extremely weak solutions.

ON MECHANICAL AND THERMAL EFFECTS ACCOMPANYING ELECTROLYSIS.*

BY M. BOUTY.†

A series of short memoirs have been published by M. Bouty in the *Journal de Physique* on a branch of the subject not very immediately connected with that which at present concerns us. I had occasion to refer to part of them in a communication on the seat of E.M.F. in the voltaic pile. (*See* "B.A. Report," 1884., pp. 492 and 513, or *Phil. Mag.*, Vol. XIX. 1885, pp. 189 and 343 to 350.)

The references to them are as follows:—

1. *On some mechanical and thermal effects accompanying electrolysis* (*Journal de Physique* 1879, T. VIII. pp. 289 and 341).

2. *Thermo-electric and electro-thermic phenomena at contact of metal and liquid* (1880, T. IX. p. 306).

3. *On the contraction of galvanic deposits, and its relation with the Peltier phenomenon* (1881, T. X.)

In the first of these papers metals are deposited on silvered thermometer bulbs and the mechanical compression of the different deposits studied, Wertheim's results in elasticity being applied to them.

The effect of heat on such metallised thermometers is also discussed.

Metallised thermometers are then used as electrodes to examine the changes of temperature which occur while various ions are being liberated. During the electrolysis of $CuSO_4$ or $ZnSO_4$ the anode is slightly warmed, the cathode slightly cooled; inverting the current cools the new cathode distinctly. Electrolysing dilute H_2SO_4 with platinum coated thermometers, the anode is quite warm, the cathode scarcely at all. This is the permanent effect. Inverting the current cools the old anode, sometimes $\frac{1}{6}$ degree below the temperature of the surrounding liquid. The effect can be repeated seven or eight times, although with decreasing intensity, if one takes care to stir the liquid between the inversions.

Replacing H_2SO_4 by HCl the permanent effect is very small, but both poles heat strongly at each inversion. With $PtCl_4$ one observes at each inversion a cooling of the old anode and a heating of the old cathode. In every case examined anode is hotter than cathode in the permanent state.

In the second paper, metal liquid junctions are warmed and cooled alternately, so as to give thermo-electric currents, the E.M.F. of several circuits being measured. An attempt is then made to measure absolutely the coefficient of the Peltier effect at these junctions when a current passes, a method suggested by Maxwell ("El. Electricity," p. 146) being used. The result is that the author believes the effects to be purely physical, without known relation to the heats of combination or the latent heats of solution, but connected exactly with the thermo-electric forces of couples corresponding. The thermo-electric laws of Sir W. Thomson are believed to apply without modification. Chemical effects are regarded as disturbances producing parasitic heats.

In the third paper, the author reconsiders the contraction of galvanic deposits in the light of the Peltier effect, and comes to the simple and satisfactory conclusion that the two phenomena are immediately connected. Each envelope being deposited at a rather higher temperature than it is able afterwards to maintain, a state of compression naturally results. This view he sustains by experiment.

CONTRIBUTION TO OUR KNOWLEDGE OF THE ACTION OF ELECTROLYSIS ON AN ELECTROLYTE (BEHAVIOUR OF JELLY).*

BY SVANTE ARRHENIUS.

From numerous researches of physicists† it has been held as proved that resistance to the passage of an electric current undergoes the same variations as the internal friction—*i.e.*, that both increase or decrease simultaneously. This view is based on a considerable number of data regarding the conductivity of salts in aqueous solution. To obtain further knowledge on the subject it was necessary to test the action of solvents other than water. This has been done by C. Stephan,‡ who investigated the behaviour of alcoholic solutions, and found only an analogy between electric resistance and internal friction, but not complete proportionality; and this has been

* *Journal de Physique*, 2e sér. September 1885, T. IV.
† Brief abstract, by Oliver Lodge.

* Translated from *Kongl. Vetenskaps-Akademiens Förhandlingar*, 1885, No. 6, Stockholm. By Professor W. Ramsay.
† Among others G. Wiedemann; a detailed description of the work of others is to be found in his *Electricity*.
‡ Wiedemann's *Annalen*, 1882, XVII., p. 673.

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confirmed by other observers.* That proportionality exists, except in some exceptional cases considered by Stephan,† cannot be held. Unfortunately Stephan has only investigated alcoholic solutions containing from 0 to 70 per cent. of alcohol—*i.e.*, those of which the internal friction is greater than that of water. Had he investigated solutions richer in alcohol, he would doubtless have found that an alcoholic solution of a salt has less conductivity as the corresponding more aqueous solution, in spite of the former having less internal friction than the latter. This has been clearly proved by Hittorf's work,‡ and has been completely confirmed by Lenz's§ investigations, although Lenz's work was not directed to that point. I subsequently found on conversing with Prof. Ostwald, of Riga, that he, like myself, disbelieved in any connection between internal friction and resistance, and he proposed that I should undertake the investigation of which an account follows. From a paper by H. de Vries‖ it follows further that the rate of diffusion of a solution of salt is nearly independent of internal friction; a result which Graham's experiments clearly indicate. Lastly, Long's¶ work shows that the rate of diffusion of an aqueous solution of salt is nearly proportional to its conductivity, whence it follows with high probability that the resistance must be nearly independent of internal friction under similar conditions. And should this prove to be true, the whole of our knowledge of the process of electrolysis would be much simplified.

The method of investigation was that proposed by Kohlrausch and Nippoldt.**

The resistance vessels were of the same form as those I previously used. The platinised platinum terminals were 15·5 mm. apart, the diameter of each was 25·6 mm., and through each passed a glass tube 9mm. in diameter. The solutions investigated were solutions of sodium chloride, zinc sulphate, and copper acetate, in pure water, and also in water in which had been dissolved 4·2 per cent. of commercial gelatine.

The proportions taken were : (*a*) 20 cc. of the salt solution diluted to 25 cc. with water ; (*b*) 20 cc. of solution, in which 1·05 gram gelatine was dissolved, diluted to 25 cc. The gelatine solutions were tolerably fluid at 30°, at 25° very thick and syrupy, at 24° the traces of fluidity were extremely small, and at 23·5° the whole had jellied.

The internal friction was determined by Sprung's†† method for the gelatine solution containing 4·2 per cent. of gelatine, and was found to be : at 30·5° C. = 2,271, at 27·7° C. = 2·889, the internal friction of water being taken as unity at 0°. At 24° the internal friction was infinitely great, *i.e.*, the solution had gelatinised and blocked the capillary tube. At corresponding temperatures the internal friction of water is at 30·5°, 0 4475 ; at 27·7°, 0·4547 ; and at 24°, 0·5171. The internal friction of the employed weak salt solutions can only have differed but very little from these numbers.

The distilled water showed a resistance of 60,000 ohms, while the gelatine solution averaged 300 ohms. It was therefore considered unnecessary to introduce a correction for the conductivity of the distilled water present. Now, as it is known that all organic substances which do not possess well-marked acid, basic, or salt-like properties have extremely small conductivity, it may be concluded that gelatine also, if free from salts, should manifest great resistance, and the high conductivity of the gelatine is evidently due to the salts which it contains.

The gelatine solution was warmed in a water bath to 35° C. Simultaneous measurements were made of temperature and resistance. As the water cooled the former fell, while the latter slowly rose.

The following table shows in the first column the observed temperatures, and in the second the resistance in British Association units. From these data the conductivity was

* E. Wiedemann has proved this to be the case with solutions in glycerine (Wiedemann's *Annalen*, 1883, p. 20).
† Stephan's figures do not exhibit this proportionality. The ratio is not a constant one.
‡ Poggendorff's *Annalen*, 1859, CVI., p. 554.
§ *Mém. Acad. Imp. St. Pétersbourg*, sér. 7, p. 30, No. 9.
‖ Beiblätter, 1885, p. 160. ¶ Wiedemann's *Annalen*, IX., p. 623.
** Poggendorff's *Annalen*, CXXXVIII., pp. 280 and 370.
†† *Ibid.* CLIX. p. 1.

calculated in arbitrary units (according to the formula $l = \frac{10000}{m}$, m being the resistance given in the second column); the values of l are given in column three. The fourth and fifth columns exhibit the differences of the temperatures and the conductivities.

TABLE I.—CONDUCTIVITY OF GELATINE SOLUTION.

t	m	l	Δt	Δl
14·5°	289·8	34·51		
			2·3	2·03
16·8	273·7	36·54		
			1·0	0·94
17·8	266·8	37·48		
			2·3	2·41
20·1	250·7	39·89		
			1·2	0·99
21·3	244·6	40·88		
			1·0	0·96
22·3	239·0	41·84		
			0·9	10 89
23·2	234·0	42·73		
			0·8	0·96
24·0	228·9	43·69		
			0·9	0·97
24·9	223·9	44·66		
			1·1	1·04
26·0	218·8	45·70		
			1·1	1·10
27·1	213·7	46·80		
			1·1	1·12
28·2	208·7	47·92		
			1·1	1·20
29·3	203·6	49·12		
			1·1	1·26
30·4	198·5	50·38		
			2·2	2·7
32·6	188·4	53·08		
			0·8	1·48
33·4	183·3	54·56		

The results with the gelatine solutions to which salt had been added are given in the Tables on next column.

Here it is evident that the conductivity alters only uniformly with temperature, for had this been otherwise great variations in the neighbourhood of 24° should have been noticeable, for the internal friction increases about that temperature from a moderate value to an infinitely great one. But no sign of such a sudden variation can be deduced from the above figures. The calculated values of the coefficient of temperature for gelatine solution are

Gelatine solution.	Sodium chloride.	Zinc sulphate.	Copper acetate.
0·0281	0·0244	0·0243	0·0248

and for aqueous solutions

	0·0238	0 0234	0·0213

Those for gelatine solutions are generally somewhat higher than for the corresponding aqueous solutions, but the difference is unimportant. It it be assumend that the coefficient of temperature for infernal friction and conductivity is the same for aqueous solutions, this cannot be extended to gelatine solutions, for which the temperature-coefficient of internal friction must evidently be infinity (inasmuch as the coefficient of conductivity never exceeds 0·03). If the conductivity of pure aqueous solutions at 17·8°, which are very mobile, be compared with that of gelatine solutions of 4·2 per cent. containing the same amount of salts, which are solid at 24°, the following table results :—

	Sodium chloride.	Zinc sulphate.	Copper acetate.
Aqueous solution......	250·6	169·6	159·9
Gelatine solution	205·6	140·3	134·2
Difference...............	17·9 per c.	17·3 per c.	16·1 per c.

The gelatine solution has accordingly about 17 per cent less conductivity than the corresponding aqueous solution. The found difference of 17 per cent. is not of the magnitude which might be expected if internal friction had really the effect usually attributed to it.

Let us now examine the reasons for assuming parallelism between internal friction and conductivity. In most cases

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TABLES *showing the Results with the Gelatine Solutions to which Salt had been added.*

GELATINE SOLUTION WITH SODIUM CHLORIDE.

t	m	l	Δt	Δl
15·3°	43·6	194·1		
			5·1	23·4
20·4	38·8	217·5		
			4·4	23·6
24·8	35·0	241·1		
			3·4	17·1
28·2	32·6	258·2		
			4·2	22·3
32·4	30·0	280·5		

GELATINE SOLUTION WITH ZINC SULPHATE.

t	m	l	Δt	Δl
14·0°	61·6	128·3		
			3·9	12·4
17·9	56·1	140·7		
			3·8	8·2
21·7	52·5	148·9		
			4·3	16·8
26·0	47·3	165·7		
			4·0	14·3
30·0	43·5	180·0		
			1·5	8·3
31·5	41·7	188·3		

GELATINE SOLUTION WITH COPPER ACETATE.

t	m	l	Δt	Δl
15·0°	62·0	126·3		
			4·1	11·5
19·1	56·6	137·8		
			3·0	9·2
22·1	53·0	147·0		
			3·5	11·8
25·6	49·0	158·8		
			4·4	13·5
30·0	45·0	172·3		
			2·6	12·7
32·6	42·0	185·0		

the molecular conductivity in aqueous solutions decreases with increase of concentration, and similarly the fluidity. These relations hold, with few exceptions, for aqueous solutions, and it is therefore not remarkable that the fluidity and the molecular conductivity of aqueous solutions should vary at about the same rate. But it does not follow that they are interdependent or to be ascribed to the same cause. If very dilute solutions be employed the fluidity remains nearly constant, but the molecular conductivity of salts increases considerably with dilution, as I have shown in my former work, and my results have been confirmed by Kohlrausch.*

There cannot therefore be a complete parallelism between fluidity and conductivity in aqueous solutions. For very dilute solutions our present views of the nature of electrolysis lead us to conclude that the variation in conductivity is dependent on chemical change, such as the breaking down of complex molecules, the union of molecules of salt with molecules of water, and so on. And the difference between dilute and concentrated solutions is merely a relative one. We cannot draw any definite line between bodies in dilute and in concentrated solution. Thus strong acids in concentrated solution pass through precisely the same phases as weak acids in dilute solution. There is the same relation between alkali salts, on the one hand, and mercury salts on the other. The conclusion follows, therefore, that the molecular conductivity depends chiefly on chemical relations. And there appears no reason to connect internal friction with molecular changes of a chemical nature.

* *Göttinger-Nachrichten*, 25th Feb., 1885,

A similar relation holds between the temperature coefficient for fluidity and the conductivity. These are for dilute solutions approximately comparable, and it might be expected that in extremely dilute solutions they should coincide. I have shown* that such a relation does not hold either for aqueous or alcoholic solutions. Bouty,† who found complete correspondence between these two quantities, was misled by a coincidence in calculating his results, as Kohlrausch has shown.‡

As all known cases can therefore be explained without assuming a connection between internal friction and conductivity, this theory, which serves only to complicate matters, must be for the present abandoned.

As a final proof of the justice of the above conclusion I made a cell like an ordinary Daniell, but introduced gelatine into the solutions of zinc sulphate and copper sulphate. The resistance was 1·5 ohm, while that of a similar Daniell's cell was 1·3 ohm. But the resistance of the cell containing gelatine gradually increased after four days, owing to bubbles being deposited in the gelatine near the zinc and the copper.

CONTEMPORARY PROGRESS.§

ON THE FORM OF THE WAVE SURFACE OF LIGHT IN AN ISOTROPIC MEDIUM IN A UNIFORM MAGNETIC FIELD,

AND

The Probable Existence of a Special Double Refraction in a direction Normal to the Lines of Force.

By A. CORNU, *Comptes Rendus*, Vol. XCIX., Dec., 1884.

AND

An Experimental Verification of Verdet's Law in Directions nearly Normal to the Lines of Magnetic Force.

By A. CORNU and A. POTIER, *Comptes Rendus*, Vol. CII., Feb., 1886.

It is known that a transparent isotropic medium acquires, in a magnetic field, a rotatory power in the direction of the lines of force. Verdet showed by experiment that the rotation of the plane of polarisation is proportional to the intensity M of the magnetic field, and to the cosine of the angle α which the luminous ray makes with the lines of force.

If we write ν' and ν'' for the velocities of propagation of plane waves with circular left-handed and circular right-handed vibrations respectively, Verdet's law interpreted on Fresnel's theory gives to the order of approximation comparable with that of the measurements

$$\nu'' - \nu' = 2k\,\mathrm{M}\cos\alpha$$

whence for light of a given wave-length $2k$ is a constant depending on the isotropic medium.

The author has previously shown experimentally (*C.R.*, Vol. XCII., p. 1368) that the mean velocity of propagation of the opposite circular waves separated by the magnetic action is sensibly equal to their common velocity ν, when there is no magnetic action; so that

$$\nu' + \nu'' = 2\gamma$$

We have, then, assuming the accuracy of the experimental laws,

$$\nu' = \nu - k\,\mathrm{M}\cos\alpha,$$
$$\nu'' = \nu + k\,\mathrm{M}\cos\alpha,$$

Fresnel's geometric method will therefore give the wave surface in the medium when subject to magnetic action.

(Verdet's law alone would not be sufficient, for, though it gives $\nu' + \nu'' = 2u$, it does not require that u should be independent of α, and if it is not, the elimination required to obtain the envelope could not be effected.)

Let each plane wave be referred to rectangular axes with origin O, and with the axis of x parallel to the lines of force of the field. The required wave-surface will be the envelope of

* *Bihang t K. V. As. Handlo*, 1884, p. 45.
† *Comptes Rendus*, 11th Feb., 1884.
‡ *Gött. Nach.* 1885, p. 86.
§ Compiled and translated by G. W. de Tunzelmann. Continued from No. 21, Vol. XVII.

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a plane whose distance from the origin is equal to the normal velocity of propagation.

The equation of this plane in the usual notation is

$$x \cos \alpha + y \cos \beta + z \cos \gamma = \nu \pm k \mathrm{M} \cos \alpha$$

or $$(x \mp k\mathrm{M}) \cos \alpha + y \cos \beta + z \cos \gamma = \nu \quad . \quad . \quad . \quad (1)$$

with the condition $$\cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma = 0 \quad . \quad . \quad . \quad (2)$$

Differentiating these two equations with respect to $\cos \alpha, \cos \beta$, $\cos \gamma$, as variable parameters and separately equating the coefficients of the independent differentials to zero, we obtain as the equations of the radius vector from the origin to the point of contact

$$\frac{x \mp k\mathrm{M}}{\cos \alpha} = \frac{y}{\cos \beta} = \frac{z}{\cos \gamma} = \frac{1}{\nu} \quad . \quad . \quad . \quad (3)$$

and eliminating $\cos \alpha$, $\cos \beta$, $\cos \gamma$, by means of (2), we get as the equation of the wave-surface

$$(x \mp k\mathrm{M})^2 + y^2 + z^2 = \nu^2 \quad . \quad . \quad . \quad . \quad (4)$$

which consists therefore of two spheres, having the line joining their centres parallel to the lines of magnetic force, one corresponding to the right-handed and the other to the left-handed circular waves.

We therefore have the two following results :—

1. In an isotropic medium in a uniform magnetic field the two sets of waves with opposite circular vibrations (the only waves which can exist), have spherical wave surfaces identical with the spherical wave surface of the medium in its normal condition, with their centres symmetrically displaced along the lines of force.

2. This magnetic displacement is proportional to the intensity of the field, and to the electro-optic constant of the medium.

Special Directions of Circular Magnetic Double Refraction.—If we consider the plane waves propagated perpendicularly to the lines of force, Verdet's law shows that their normal velocities of propagation will be equal, since, under these conditions, there is no rotation. In fact, parallel tangent planes to the two spheres will coincide when they are also parallel to the line of centres, but it also follows that every plane parallel to this line will touch the wave surface in two points, one on the sheet belonging to the right-handed circular vibrations, the other on that belonging to the left-handed vibrations, and the two points will lie in the same plane as the line of centres. Thus the two pencils of light (the *rays* of ordinary double refraction) are separated by an appreciable angle, although the corresponding plane waves coincide ; which leads us to infer the probable existence of a special double refraction in the direction normal to the lines of force—that is, the direction in which it is usually supposed that there is no magnetic action upon light.

The author has hitherto been unable to verify this special double refraction experimentally, owing to its amount being so extremely small. As Verdet's law has only been verified in directions for which the magnetic rotation is considerable, and its exactness has been disputed, MM Cornu and Potier have endeavoured to verify it experimentally for directions nearly normal to the lines of magnetic force. The object which they had in view, in addition to the importance of the law itself, was to show that the two sheets of the magnetic wave-surface cut each other at a finite angle, and that their form is truly spherical. Faraday having discovered that the magnetic rotation ω vanishes in the direction normal to the lines of force, and changes sign when the luminous pencil crosses from one side to the other of this direction, it follows that the angle ω must be an uneven function of the angle β, which the pencil makes with the normal to the lines of force, so that

$$\omega = b\,\beta + c\,\beta^3 + \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

The question to be solved is to determine whether the term in β really exists, the existence of such a term involving, as is easily shown, the consequence that the two sheets must cut at a finite angle proportional to b. If Verdet's law is exact this term must exist, for the law may be expressed in the form

$$\omega = a \cos \left(\frac{\pi}{2} - \beta\right) = a \sin \beta = a \left(\beta - \frac{\beta^3}{6} + \quad . \quad . \quad . \quad . \right) \quad . \quad (6).$$

The coefficient b of (5) must clearly be identical with a of (6), and therefore the result to be sought was a verification of the latter equation. The experimental difficulties were :—

1. To obtain a magnetic field of sufficient intensity to give a measurable rotation in spite of the unfavourable conditions of obliquity. To succeed in this, the tranverse dimensions of the field must clearly be somewhat large in order to increase the rotation by the length of path traversed.

2. To secure that the portion of the magnetic field used for the experiments should be sensibly uniform. The source of electricity used consisted of a Gramme machine and thirty accumulators. The first condition was fulfilled by using elongated electro-magnets with thick pole pieces bent back round the central core, somewhat resembling the hollow electric magnets of Nickles, but differing in the shape of the space containing the wire, which was made in the form which calculation showed would give the maximum external magnetic effect with a given weight of copper wire. Two similar electro-magnets were placed opposite to each other a small distance apart. The free surfaces of the iron cores were about 32cm. in length by 3cm. in depth, and the space between the opposed surfaces formed a field, whose mean intensity reached the value of 6,000 C.-G.-S. units for a distance of 1·3cm. For greater distances the intensity was sensibly in inverse proportion to the distance between the cores.

The intensity was determined by the throw, δ, of a ballistic galvanometer needle due to the maximum induced current produced by a coil having a total surface s (sq. cm.), and turning about an axis perpendicular to the lines of force. The intensity M being given by the formula

$$\mathrm{M} = \delta \frac{\mathrm{E\,C\,R}}{s\,\delta_1} 10^2.$$

The value of the galvanometer throw was determined by observing the throw δ_1, produced by the discharge of a condenser of capacity C microfarads, charged by an E.M.F. of E volts, R being the resistance of the galvanometer.

In the magnetic field, extending horizontally to a length of 32cm., was placed a tube containing a saturated solution of red mercuric iodide and potassic iodide (Thoulet's solution), whose rotatory power is three times as great as that of carbon disulphide. The tube was movable about a vertical axis, and capable of being inclined at an angle of 5° on one side or other of the median line of the field ; with a length of 30cm. with the extreme inclinations the rotation obtained was $\pm 9°$, which could be relied on within 1/200.

The second condition with regard to the uniformity of the field was difficult to fulfil, and, indeed, the results first obtained were only in approximate agreement with Verdet's law. The question then arose whether the want of agreement was to be attributed to inexactness of the physical law or to an insufficient fulfilment of the theoretical conditions.

Clearly, owing to their small thickness, the cores could not give an approximately uniform field, and, though this might have been remedied by using large armatures, it would have resulted in too small a magnetic intensity, the intensity of the field being inversely proportional to the areas of opposed surfaces of the cores. Fortunately, an actual uniformity in the field was not necessary for the experiments, for by Verdet's law the rotation $d\,\omega$ in an element of length $d\,s$ is given by the equation,

$$d\,\omega = \mathrm{A}\,ds\,\mathrm{M} \cos \alpha$$

where A is the electro-optic constant of the medium, and we have $$\mathrm{M}\,ds \cos \alpha = d\,\mathrm{V}$$

where V is the magnetic potential, and therefore

$$\omega = \mathrm{A} \int_{s_0}^{s_1} \mathrm{M} \cos \alpha\, ds = \mathrm{A} \int_{\mathrm{V}_0}^{\mathrm{V}_1} d\,\mathrm{V} = \mathrm{A}\,(\mathrm{V}_1 - \mathrm{V}_0)$$

It was only necessary, then, to show that equal rotations were produced in two columns differing in length, but whose ends were in the same two equipotential surfaces. If in a suitably selected plane, the equipotential lines are rectilinear and parallel, the relation between the lengths $l\,l_1$ of the two columns having their ends on the same two equipotential lines will be

$$l \sin \beta = l_1 \sin \beta_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

(β and β_1 being the angles made by the two columns respec-

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tively with the lines of force), the same as if the fields were uniform.

This condition is realised in the horizontal plane of symmetry of the cores when their distance is small compared with their length, as may also be shown experimentally by means of iron filings. The experiments were made by placing in this plane a tube containing the solution and having at its middle point a transverse branch one-tenth of its length, the rotation of a ray traversing the long branch l at different inclinations β to the medium line of the field, and the observations repeated with the short branch l_1 placed parallel to the lines of force ($\beta = 90°$). The experimental verification then reduced itself to showing that the special value of β which gave the same rotation in each of the two branches satisfied equation (3). The results of the experiments agreed well with the calculated values, the error never being more than about 2 per cent., and always showing a slight excess of the calculated over the observed value, indicating that the errors were due to a want of uniformity in the field, and not to inexactness in the law.

Note.—In the *Journal de Physique* for May, 1886 (2nd Series, Vol. V., p. 199), there is a paper by the same authors giving a more detailed account of the experiments, and in this paper the construction of the electro-magnets is described.

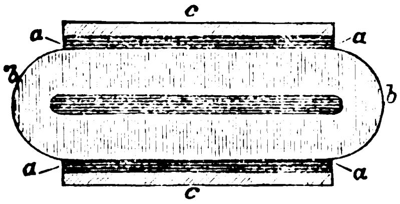
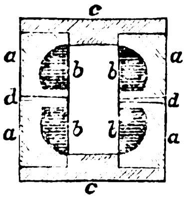
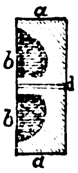

Fig. 1. Fig. 3. Fig. 2.

They are shown in Figures 1 and 2. *a a* are the iron cores, with pole pieces made to surround the coils *l b*, which are kept in position by brass side pieces.

The two electro-magnets were arranged as shown in Fig. 3, being connected by two pieces of soft iron *c c*, an arrangement which was found to increase the intensity of the magnetic field in the ratio of 3 to 5. The blocks *a* were pierced with conical apertures, one in the centre of each block, and the others at distances of 15cm. on either side, to permit the passage of beams of light through the field between the two magnets in a direction parallel to the lines of force.

ON THE ELECTRICAL CONDUCTIVITY OF SOME EASILY FUSIBLE ALLOYS.

By C. L. Weber, *Wied. Ann.* Vol. XXVII., 1886.

The substances treated of in this paper belong to a class showing remarkable variations in molecular structure, *viz.:* fusible alloys of lead, cadmium, bismuth, and tin, and more particularly three special alloys whose variation in volume with the temperature has been made a subject of research within the last few years by Spring, and E. Wiedemann. (Spring, *Bul. Brux.* XXXIX., page 548, 1875, and E. Wiedemann, *Wied. Ann.*, Vol. III., page 327, 1878.)

These are—

Rose's alloy,

48·9 Bi; 23·55 Sn; 27·54 Pb,

Lipowitz's alloy,

49·98 Bi; 12·76 Sn; 26·88 Pb; 10·38 Cd,

and Wood's alloy,

55·74 Bi; 13·73 Sn; 12·73 Pb; 16·80 Cd.

The alloys were melted in an atmosphere of pure hydrogen to avoid oxidation. The measurements of resistance were made with a Thomson bridge, the metal being contained in a U-shaped capillary tube immersed in a glycerine bath.

As the temperature was varied, the changes in resistance took place pretty quickly, and when the temperature ceased to change and was kept stationary the resistance soon assumed its final value.

It was found, however, that the alloys were also subject to a variation of about 3 per cent. of the whole resistance when they were kept for several days at the ordinary temperature. Nevertheless, the general variation of resistance with temperature was found to be the same in each set of experiments.

In the subjoined diagrams the results of the experiments are shown by means of curves, of which the abscissæ represent temperatures and the ordinates represent the specific resistances of the metal, that of mercury being taken as unity.

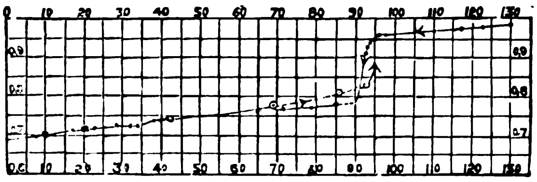

Fig. 1.—Rose's Alloy.

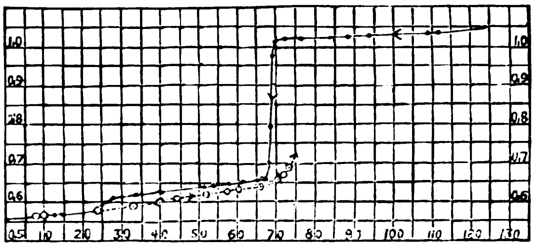

Fig. 2.—Lipowitz's Alloy.

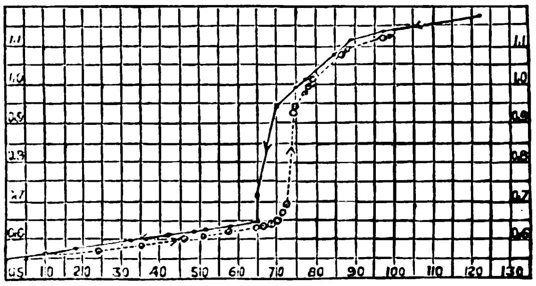

Fig. 3.—Wood's Alloy.

It will be seen from the diagrams that in the liquid state the resistances only vary slightly with the temperature; for example, the temperature coefficient for Rose's alloy in the liquid state is ·0007, and for Lipowitz's it is ·0005.

At the instant of solidification the specific resistances decrease suddenly, as is the case with pure metals, but with the latter this sudden decrease is much greater. When the metal is gradually cooled until it solidifies, the resistance gradually diminishes again, but between 20° and 30° a fresh sudden change takes place, not to the same extent as the first, but very noticeable, nevertheless, in the case of the last two alloys.

If these results be compared with those obtained by Spring for the changes in volume, they are found to differ completely, the curves for the volumes having several maxima and minima, while the changes are most noticeable in the case of Rose's alloy. The two sets of phenomena are not therefore mutually dependent, but they are both due to changes in molecular arrangement. The curves obtained with an increasing temperature are somewhat different from those obtained with a diminishing temperature, being perfectly continuous from 0° to the temperature of fusion, which in this case is higher, as has already been observed by Wiedemann, who considered it to be analagous to the similar phenomenon exhibited by supersaturated solutions.

Wood's metal presents a special peculiarity in the neighbourhood of its melting point, for when slowly cooled down to the temperature of solidification the curve of electrical resistance, previously nearly rectilinear, assumes a more rapid slope, while remaining rectilinear, which is maintained throughout a fall of from 15° to 25° until the solidification point, nearly 70°, is nearly reached, when there is a sudden sharp fall. It would

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therefore appear that between the liquid and solid states there exists an intermediate state of aggregation, which is stable so long as the temperature is maintained constant, and which is characterised by a special temperature-coefficient.

Wiedemann's explanation of the phenomenon is that at the temperature of 69°, which may generally be taken as the fusing point of Wood's alloy, only a portion of the metal becomes liquid, the rest dissolving little by little, the state of a homogeneous liquid being reached only when the temperature is increased up to 90°.

It appears that this state has no influence on the specific volume, and that the variations in temperature which occur during this time are too small to be shown in the curves of cooling given by Spring.

DYNAMO DESIGN.

In a recent issue of *L'Electricien* M. R. Arnoux has a paper criticising somewhat severely the note recently presented to the *Academie* by M. Marcel Deprez on the magnetic circuit. (An abstract of this note will be found in our issue of November 12th, p. 15.) M. Deprez affirms that "contrary to the views of many electricians, the intensity of the field decreases much less rapidly than the distance of the poles increases." But M. Arnoux points out that according to the figures given by M. Deprez himself, the whole of the experiments upon which this conclusion was based were conducted with exciting powers far beyond the saturation point of the iron. In fact, in well designed machines field-magnets of the same dimensions as those employed in the experiments would be excited with an expenditure of energy not exceeding one-eighteenth of that actually expended by M. Deprez. Under these circumstances, the observations cannot be considered to have any bearing upon the practical questions to which M. Deprez wishes to apply them. In the course of his remarks M. Arnoux mentions that he has himself experimentally established the following theorem :—In a machine of given dimensions, and for a given exciting power, there is always a certain value for the diameter of the inter-polar space, and one only, for which the output of the machine will be a maximum, and one other value, and only one (always less than the former), for which the commercial efficiency will be a maximum.

CLAUSIUS ON ELECTRICITY AND ITS RELATION TO HEAT.

In the German review, *Natur und Leben*, H. Klein, referring to a recent work of Clausius, mentions that the latter strongly insists upon the erroneous character of certain expressions which are in frequent use, especially the phrases "the transformation of heat into electricity," and the converse. Electricity in fact is *not* a form of energy, any more than water or air ; like these, it is merely a vehicle of energy, and cannot itself undergo transformation into either kinetic or potential forms of energy. These ideas are of course perfectly familiar, but it is to be feared that it will be long before practical electricians will see their way to modify their language in accordance with them. Clausius goes on to say that he is gradually becoming more and more convinced that we should cease altogether to talk of "ether," and should deal with radiant heat and light solely in terms of electro-magnetic reaction, and of Maxwell's "electric particles."

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The following is the continuation of the discussion on Mr. Kapp's paper, "On the Pre-Determination of the Characteristics of Dynamos" :—

Dr. JOHN PERRY said that Mr. Kapp's paper was one which was calculated to do immense good to the members of the Society. The description of the method of calculation was exceedingly easy to follow, even by the most unmathematical manufacturer, and even if exact calculations were not made, the principle underlying the method was the only good guide yet given to the makers of dynamo machines ; it might be said to have revolutionised the construction of such machines. And although Dr. Hopkinson may have used the method first, it had to be remembered that, when Mr. Kapp became convinced of its usefulness, he published it, putting it freely at the service of all engineers. Our gratitude to Mr. Kapp ought to be shown in an unmistakable way. As time was valuable, the speaker would not say what he had come last night prepared to say in support of Mr. Kapp's method of dealing with the magnetic permeability of iron. Immense differences in the law for μ for increasing and diminishing magnetisation produced exceedingly small differences in the characteristic of the dynamo. Prof. Ayrton had mentioned that, with the speaker, he had since last year been experimenting to find out the best practical method of taking advantage of the magnetic and electrical analogy first enunciated by Faraday. They had measured magnetic leakage directly, and also artificially, by reversed currents between conductors immersed in liquids. If the speaker understood Mr. Kapp rightly, he, by guess and trial, determined a leakage resistance, ρ, which would enable him in his calculation to obtain the actually observed characteristic of a dynamo. He could then assume that in any similar dynamo ρ was inversely proportional to the dimensions of the machine. Dr. Hopkinson took quite a different method, and he ventured to think not so correct a method as Mr. Kapp's. He assumed a leakage, which was a constant fraction of the useful induction. He measured this directly on the machine by coils of wire and ballistic galvanometer. Neither Mr. Kapp's nor Dr. Hopkinson's method could, therefore, be applicable to a new kind of machine before the machine was constructed. It was this defect in the method, this necessity for a determination of the probable leakage, which caused the speaker to listen so intently to Prof. Forbes ; for Prof. Forbes attacked this very question. He could not say, however, that he thought Prof. Forbes's method of calculation very valuable. Prof. Forbes said that he did not have to use his judgment in making the calculation, but the speaker thought he had exercised his judgment very liberally. He settled beforehand from what places leakage took place, he settled the shape of its paths, he restricted its paths to very confined portions of space. The only fact which was mathematically certain about such a calculation was that its result must be less than the real leakage. Why did Prof. Forbes neglect utterly the leakage from the faces of the magnet limbs remote from one another ? He left out all sorts of possible leakage. To make up for this he took the leakage from limb to limb as if every point of each were at the same potential—namely, the mean potential of each, and hence his result ought to be half as much again. The speaker had no faith in the value of such a method of calculation. Prof. Forbes had a right to feel proud, not of the value of his method, but of his great good fortune in obtaining an answer which fairly well agreed with the experimental result ; every user of the method might not have the same good fortune. He understood that Dr. Hopkinson objected to the use of the analogy between magnetic induction and the electric current. Presumably this objection was not to the analogy in its essence ; but since the magnetic resistance of iron varies with the amount of induction, it is probably thought that the use of the analogy might cause this fact to be kept out of sight. But in the particular case of the field-magnets of a dynamo the speaker had gone carefully into the question, and found, assuming some such law for μ as Mr. Kapp has taken, we may, until four-fifths of the saturation induction have been reached, really regard the leakage resistance as a constant for all magnetisation. This is a point of very great importance. Mr. Kapp assumes the constancy of ρ, but Dr. Hopkinson, knowing that there cannot be an absolutely constant leakage resistance, has not seen that it may practically be regarded as constant, and he has made an assumption which is not by any means so defensible. The speaker concluded by advocating the use of a simple empirical formula like that of Frölich, which he claimed to have used for dynamos with Prof. Ayrton for some years before Frölich published it.

Mr. KAPP was then called upon to reply upon the whole discussion, and said that, before referring in detail to the various questions which had been raised during the discussion, he would like to say a few words upon a point which, he feared, had not been made sufficiently clear in the paper itself. This was the question of the relative importance of the waste field at different degrees of magnetisation. Some of the speakers appeared to be under the impression that he had denied the existence of leakage in a weak field ; but this was not his intention. What he had said was that since at low degrees of magnetisation the resistance of the armature and magnet was very little greater than its initial value, and was also very small in comparison with that of the air space, the leakage had very little influence upon the exciting power. Mr. Kapp then pointed out that in the electrical analogy this was equivalent to the case of a battery of low internal resistance doing work in a circuit. The addition of a shunt of high resistance (corresponding to the magnetic leak) would not, then, sensibly diminish the E.M.F. at the terminals of the working circuit. On the other hand, if the internal resistance of the battery be increased

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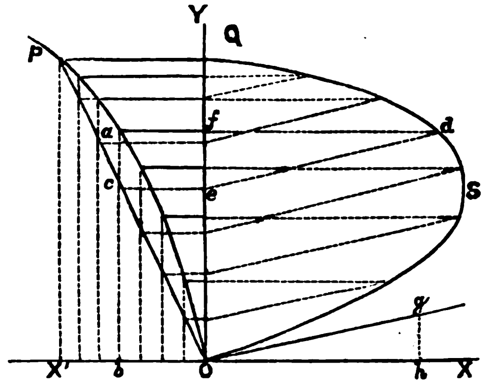
while the total E.M.F. and the resistance of the shunt be kept constant, then the influence of the shunt in reducing the E.M.F. at the terminals will become more and more apparent. This is analogous to the case in which, while the leakage resistance remains the same, the magnetisation is increased, and with it the magnetic resistance of the iron. Thus, at low degrees of magnetisation, leakage has no sensible influence, but it has an influence at higher degrees. But even at higher degrees its detrimental effect is not so great as some of the speakers appeared to imagine. He was glad that Prof. Ayrton's experiments confirmed his own views with regard to parallel resistances. (Prof. Ayrton here expressed some dissent from this statement, but Mr. Kapp pointed out that the discrepancy between his own formulæ and those of Prof. Ayrton was only apparent, the four equations contained in his own paper reducing to the simple expression for the law of parallel circuits as preferred by the Professor.) Mr. Swinburne and Mr. Esson had raised the question as to the best relative proportions between the sectional area of the iron in the field and in the armature. Mr. Esson had given some figures taken from actual practice. Unfortunately, however, he had reason to believe that in several cases these referred to machines now obsolete. As a matter of fact, no hard and fast rule could be given, as the ratio must largely depend upon the particular purpose for which the machine was to be constructed. He thought, however, that in arriving at the ratio 3 to 4, Mr Esson had reduced the relative proportion of iron in the field to as low a point as could ever be really advantageous. Mr. Fricker considered it more correct to describe exciting power in terms of ampere feet, but on taking into consideration the *area* enclosed by a coil, it would be found by an elementary investigation that this came to exactly the same thing as ampere turns. The latter form was, however, more customary and more convenient. Mr Crompton had said some very encouraging things for the benefit of our mathematicians, but he had at the same time thrown cold water upon those who were not gifted with that peculiar "eye" for details of this nature. Mr Kapp then pointed out that, so far as he was concerned, the establishment of the fact of the desirability of increasing the sectional area of the iron of the magnets dated from his discovery of a certain empirical formula for the E.M.F in a Bürgin machine, which, although now known to be incorrect, yet distinctly indicated the necessity for an increase in the quantity of iron. It was true that the final conversion was effected by the aid of a machine which Mr. Crompton had built, but which at the time he (Mr. Kapp) had characterised as containing a "ridiculous" quantity of iron. But it was also true that the same machine effected Mr. Crompton's re-conversion a certain distance in the opposite direction (laughter). If it be permissible for the author of a paper to offer his congratulations to a member who has taken part in the discussion, he should like to do so in the warmest possible manner to Prof. Forbes, whose laborious and painstaking investigation of the leakage in every part of the magnetic circuit of the machine, dealt with by Dr. Hopkinson, excited his greatest admiration. In common with Prof. Perry he could not, however, avoid feeling some misgiving as to the general applicability of the method. The design for a dynamo without leakage, which had been given by Prof. Forbes, would only partially fulfil this purpose; but, on the other hand, it had a decided advantage, which he did not name, in that it saved one half of the wire on the field. Mr. Kapp then showed his design of a four-pole dynamo to effect the same purpose, and which he published about a year and a half ago in *The Electrician*. He had himself never made a machine of that construction, but he noted that a four-pole machine, of almost identical construction, was now being made, under the name of the "ironclad dynamo," by Mr. Kennedy, of Glasgow. Mr. Elwell had also, only a few hours ago, told him that he had made one of these four-pole machines quite recently, and found it very efficient, and cheap to manufacture. Dr. Hopkinson had told them something about the methods of measuring the minimum induction obtained. Upon double horse-shoe machines this measurement might be still more easily carried out in the following way:—Remove the armature and couple the four exciting coils so as to magnetise the field-magnets in a continuous direction. This will produce great crowding of the lines of force through the middle portion of the pole-pieces where the latter have least thickness. In these portions we shall therefore have saturation, and the total induction can be measured by a turn of wire round that part and a ballistic galvanometer in the usual way. Mr. Walker and other speakers had assumed that a leakage of 25 per cent. in the total number of lines meant a waste of 25 per cent. of the existing power. This, however, was not the case, for if the narrowest section of the field was increased by 25 per cent. in width, the perimeter, and, therefore, the length of the exciting coils, would under practical conditions receive a very much smaller increase, amounting in a case assumed in illustration to only 7 per cent. Prof. Silvanus Thompson complained that the true characteristic had not been given, but only the characteristics of magnetism But the problem of deducing the one curve from the other is merely a geometrical exercise, with which he did not think it desirable to occupy the time of the society. Prof. Thompson also objected to the selection of a particular point in testing the Frölich formula, but to adopt his own suggestion would have required the verification of the formula at the same point upon the curve as that selected at first. If Frölich's curve will not stand any harder test than this, we had better call it in future Frölich's point. Prof. Perry also vindicated the employment of Frölich's formula, and he was perfectly willing to admit its utility, provided always that the leakage be taken into account, which was, however, not done either by Frölich nor by Thompson. Mr. Kapp concluded his remarks in the following terms:—Now about my unfortunate units. I need hardly say that last week my heart sank within me when one speaker after another took me to task in the most severe fashion for having employed some special units. Prof. Thompson said that my system is a mixture of C.-G.-S. and inches and minutes. I beg to say that my system is no mixture, and that it contains not a single shred of the C.-G.-S. A man totally unacquainted with grammes and centimetres can use my formulæ, and will know what he is doing. Can the same be said about the C.-G.-S.? Only last week one speaker called that a gauss, which another called a milligauss, the ratio being nothing less than one to a million. Is that not a little mixed? It is significant that practical dynamo makers have not as yet raised any objection to my system. I know that Mr. Fricker, for instance, uses it and makes very good dynamos. He could use the C.-G.-S. equally well (for the translation of one system into the other is really a very easy matter), but he is content with my formulæ as they are given. The difficulty in adopting C.-G.-S. in actual work is that we cannot talk to our workmen of centimetres and grammes. We must conform to usual practice and to English measure, and therefore it saves labour to make the calculations in a system where the figures are of reasonable magnitude and are directly applicable for purposes of the workshop.

DYNAMO CHARACTERISTICS.

The following is the solution of the problem of determining graphically the external characteristic of a shunt-wound dynamo from the curve of magnetisation of its field, as given by Prof. Silvanus Thompson during the recent discussion on Mr. Kapp's paper at the Society of Telegraph-Engineers:—



Let $O a P$ be the curve of magnetisation, which for this purpose is drawn on the reverse side of the axis O Y, and let $\tan C O b$ be the resistance of the field-magnets, the current in these coils being taken along O X'. Let $\tan g O h$ be the resistance of the armature, and let the total current be taken along O X. Then each point on the external characteristic O S Q is determined by the following construction: At any point a on the curve O P let fall a perpendicular $O b$ to the axis O X'. From the point a also draw a line parallel to O X', cutting the axis O Y, and produced indefinitely upon the other side. From the point c, where $a b$ cuts the tangent line, draw $c e$ parallel to O X, and from the point e on the axis O Y draw a line parallel to the tangent line $O g$, cutting $a f$ produced at the point d. Then d is a point on the required curve. By a similar construction at as many points on O P as may be necessary the curve O S Q may be traced out.

The proof is, of course, very simple. Let E be the total internal E M.F., C the total current*, C_1 the shunt current, R_1 the resistance of the shunt, and r that of the armature, then

$$C = \frac{E - C_1 R_1}{r}$$

$$= \frac{a b - O b \,.\, \tan c O b}{\tan g O h} = \frac{a c}{\tan g O h},$$

* From the form of the diagram given by the Professor it is evident that he has obtained the characteristic for the *total* currents, instead of, as is more usual, for the current in the external circuit only. A very simple and obvious change in the construction would give the true external characteristic.

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which by construction $= \frac{fe}{\tan f d e} = fd.$

Therefore d is the point on the characteristic curve corresponding to the point a taken on the curve of magnetisation.

GLOW LAMPS, THEIR USE AND MANUFACTURE.*

BY MAJOR-GENERAL C. E. WEBBER, R.E., C.B.

It is not my intention to enter into any dissertation on the various kinds of glow or incandescent lamps which have appeared from time to time since their first use by De Moleyns, Starr, and King, between 1840 and 1850, nor do I wish to trouble my audience with the history of inventions which have led up to the so-called glow-lamp now in commercial use. The word "incandescent" or "incandescence" lamp is, like all other adjectives of four syllables, cumbersome, and the word "glow" has been adopted by many, and is for our purposes sufficiently expressive to identify a means of domestic illumination now almost as familiar to the public eye as the gas jet. From the point of view whence I beg my audience will regard the subject, it is my desire to lead them to realise that in the manufacture of glow lamps we have a rapidly growing industry, in the increase and efficiency of which they may all before long be interested. And I shall only remind them of the antagonisms of rival inventors and the struggles for precedence arising out of the same when that part of the question is necessary to my subject. It is true that the time has not yet arrived when a general audience can be expected to evince as much interest in my subject as they would naturally do in the lectures on candles or lamps delivered in this hall, but it is believed that a more general knowledge of this very interesting subject will aid in its popularisation, and will bring home to many who have not yet accepted the fact, that illumination by electricity for home purposes is a reality, and that this little bulb, containing a filament which becomes incandescent by the passage of a current of electricity, has made possible and practical a system of illumination which we who use it would gladly convince everyone is superior from a sanitary and economical point of view to any other known means. A great deal too much that is unreasoning has been said here and elsewhere as to these advantages. Allow me for a short space to draw attention to some points connected therewith. When the glow lamp was first introduced, its promoters misled the public judgment and eye by claiming for it more duty than it was able to perform. It was shown in exhibitions, where each exhibitor vied with each other in one direction, namely, in creating a blaze of light, where the little glow lamp was placed alongside the powerful and intense brilliancy of the arc electric light. The exhibition of lamps of 16 to 20 candle-power in groups became the custom, and the public was unconsciously led to compare these, in their minds, with gas jets and Argand burners of far lower real candle-power. When they went further in their inquiries with the view to practical adoption, they were immediately met by the inequality of cost, which although in the first instance is due to the outlay in plant for supplying electricity, is heavily weighted with a factor arising out of this want of consideration of the relative candle-power of the lamps and other means of lighting. Born and educated in the use of illuminants which present to the eye a soft wide gaseous flame, having a measurable iridescent surface containing incandescent particles widely dispersed, we were quite unprepared to estimate the increased power of the brilliant little line of intense incandescence that meets our view when we regard this glow lamp. Those with eyes able to bear its penetrating effects hailed it as a means of increasing light, regardless of the extravagance in using more than they actually required; and those with sensitive retina submitted to it as preferable to the overpowering glare of the arc.

From its use in exhibitions, and with the traditions of the gasfitter, electric light crept into our places of public resort, and thence into our dwelling rooms. Wherever one went, either the gasfittings were made the supports of the glow lamp, or it was hung from the ceiling, so that on entering a room lighted by a number of these pendants a brilliant line of light cut the eyes like the blow of a whip lash, rendering everything for a time obscure. Indeed, from careful study of places lighted with the glow lamp, I have come to the conclusion that the eye is much longer recovering the effects of this sudden slight paralysis of its light receptive powers than is supposed; and that this cry of more light which one hears, where the subject has been dealt with from a gasfitter's point of view, is simply due to temporary observation and loss of power to discover the true needs for illumination of the surrounding objects. In more than one club in London, where the lines I have referred to have been followed in applying electric light, although the candle-power of the latter is about three times the value of that of the lamps previously in use, there is a constant outcry from the young eyes that "there is not enough light," and from the old eyes that "they know not where to go to avoid the glare." Of the remedies suggested for this, I cannot subscribe to one which has emanated from a well-known architect which has come to my notice, namely, that as the position of the sun, our illuminant by day, is overhead and high up, out of the ordinary direction of vision, so we ought to make use of electric lights by placing them high up in our rooms, and increase their power and number, in order to make up for the loss of light due to distance. Hence the introduction of glow lamps into the ornaments of the frieze at a well-known restaurant, and their substitution for gas jets, lamps, and candles in chandeliers and sunlights. When regarding this question from the point of view of economy, we see the reason why the cost of electric lighting has so much deterred its use in competition with cheap gas; at the same time the still cheaper arc electric light is ignored or condemned. The screening of glow lamps from direct vision adds still further to the cost of lighting, but if arc lamps were more used their cheapness would allow of much light being wasted in concealing their brilliancy by deriving the light only from reflecting surfaces. The efficiency of arc lamps is now so well secured that the old objections to them should fast disappear. That concerning the so-called ghostliness of the light has been completely dispelled by the experiments of Captain Abney and others on the subject of the colour of the electric light.

The conclusions I have come to, after visiting electric light installations at home and in many parts of the Continent, are that with all kinds of electric lamps used in interiors, the eye ought never to be allowed to meet the source of light, even when subdued 30 per cent. by transmission through obscuring media; that arc lamps should be employed in all large spaces, placed well overhead, and as much as possible so that their rays shall meet the eye of the uplooker by reflection only; that glow lamps should be invariably shaded from the eye, and so placed as to be as near as possible to the object to be seen—for instance, on brackets attached to the frames of pictures with opaque reflectors; for dining tables with white table cloths, well concealed in nearly opaque shades. For reading or writing, small candle-power lamps are ample, and least injurious to the eye if concealed in opaque shades suspended from curved table stands about twelve inches from the paper. For general illumination of rooms the shades may be more or less semi-opaque, but the reflectors or diffusers should be as brilliant as possible. Lately, the Council of the Royal Albert Hall has been making a few experiments in the distribution of light within that noble building. Both arc and glow lamps have been tried; the former in the upper, the latter in the lower part of the hall. With the arcs it was found that only in the upper arcade could they be concealed from the eyes of the audience. The effect of brilliantly lighting it up with twelve 2,000 candle-power arcs was good; but the light reflected into the body of the hall by the back wall was probably only one-tenth of that yielded. Six more such lamps placed high up in the lantern were of no more use than moonlight would have been; but when lowered below the level of the cornice gave directly or by reflection their full effect. When all the eighteen were suspended in a group and let well down into the body of the hall, the illuminating effect on objects was inferior to that of the thirty-two gas pendants, each with sixty gas jets, which are suspended all round the hall just above the arcade; but when one turned the back to the light the same print was equally easily deciphered.

What the effect of diffusing the light of such a group would have been if the lamps had been confined in an obscured glass lantern remains to be proved. Advocates of concentration and of dispersion of the arc lamps were found; but when it came to the concentration or dispersion of the glow lamps used in the trial, there was little difference of opinion as to the good effect of throwing the light from them towards the backs of the boxes, by placing them under the ceilings of each box, and concealing them from the eye of the audience. Some will recall the gloomy cavernous effect of the three tiers of boxes at the Royal Albert Hall; lighted up, as some of them were for the trial I am describing, the scene was pronounced fairy-like. The lights were placed so as to be of no inconvenience to the occupants; but the effect was to lighten the whole aspect of the elevation, and as every lamp was concealed, the eye could dwell on features of construction and colour which before were no more than masses of shade. This concealment of the glow lamps was also carried out on the orchestra stage under the organ, where the trial was equally successful in demonstrating the fact that, although the loss of light may be considerable, by following such a course that loss is a gain when it can be proved (of which there is no doubt) that the eye is far better able to examine the objects around the concealed lights than if they were exposed. It is curious how in theatres this theory of the advantage of concealment of light is carried out on one side of the house and not on another. At Buda Pesth I saw this well exemplified, where a large theatre was being lately lighted by electricity. Above the stage, and concealed among the suspended scenery, were seven treble rows of twenty glow lamps, arranged so as to be altered, raised, and lowered in various ways, but, alike with the footlights, not one could be seen by the audience; whilst in the auditorium itself the gasfitter again resumed his sway, and between chandeliers and brackets on the fronts of the boxes and galleries, the lights were successfully placed so that the dazzled eye could not dwell for a moment on the beauties, either physical or decorative, of a very beautiful building, crowded with an audience which came as much to be seen as to see. A very simple example will enable you to realise what most who have thought of these matters well understand, namely, the entirely different conditions which are being dealt with in using candles, lamps, or electric glow lamps. Photometrically each of these yield light of the value of about ten candles; but how different is the impression on the eye. Does it not show that these must be dealt with and employed differently in their use for illuminating our hours of darkness and to meet our various wants. Because artists love and seize on the effects of highly contrasting light and shade to perpetuate striking scenes, there is no reason why we should live under such conditions. Though a beautifully dressed woman may appear to great advantage for a minute under a brilliant flood of light, she would, I think, sacrifice the full effect of her splendour rather than always remain long under its influence.

One might go on for ever with examples of this kind. The real cause of so much difference of opinion on the question probably lies in the varying conditions of the human eye, in respect to its sensitiveness of light, and its power to recoil from its effects before temporary injury has been done to it.

From the manufacturing point of view, the glow lamp consists of three distinct parts, namely:—The filament, the wire mount or conductor, the glass bulb. The amount of research and experiment which has led to the perfection which now we may safely say exists in these three has been very large. It would be invidious to particularise individual labours, and the list would be too long to occupy the time of the present occasion. The burner, or bridge, has been the subject of a large part of these labours.

* Paper read before the Society of Arts, Wednesday, December 8, 1886.

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The conditions which it should fulfil are various, and a good filament for the purpose has been produced from various materials. But the object of most inventors has been to find a highly refractory substance, and they have all ended in using carbon of either a fibrous or amorphous consistency, which they produce in the shape and of the nature which they require, by various processes. The conditions of form, density, uniformity of section, surface and electrical resistance, with which a glow lamp bridge must be endowed are now well understood. First, the form has been governed by the need to hold within a bulb of a given size a carbon wire of a given length. The simplest example of the means resorted to to achieve this is shown in this lamp, in which it will be seen that by giving the filament a coil, one of about seven inches in length is contained in a bulb only three inches in length, without unduly approaching the glass. Another condition of form is that of uniformity of section. With some of the raw materials used, it is almost impossible to obtain this in the early preparation without gauging them in a die, by means of which the irregularities of surface are scraped off before the thread or strip is bent into form previous to baking. This is the case with the material of the Edison filament, of the preparations of which, from especially selected bamboo in all its stages, we have seen beautiful examples at the Paris and Crystal Palace Electric Exhibitions. It is not the case with the filaments prepared by squirting a viscous solution of cellulose into a precipitating solution, a process which produces at once the most perfect uniformity of section, such as that used for making the filaments, for instance, of the Victoria Brush glow lamp. It will be at once understood that the after stage of deposing carbon by the process discovered by Marcel Deprez is not essential to the obtaining of such uniformity in the latter case as it is in that of other inventors, who carve it out of raw vegetable material of either a fibrous nature, or out of strips of paper or parchment. Most of these raw materials are by way of being trade secrets ; indeed, in the case of one glow lamp maker on the Continent, I know that the inventor has never divulged his secret, and that he prepares the raw material in the privacy of home, and brings it to the works in such a form as almost to defy detection of its origin.

The raw material is generally wound on to blocks of carbon, and then baked at high temperatures. Here, again, we have a stage in the preparation of filaments which has given rise to a great deal of labour and research. The reasons for the varying results obtained from bakings were at first very obscure. With some kind of materials, filaments off the same blocks, and off different blocks, showed differences of contraction, causing fracture in the process, differences of tensile strength, and of surface, for which it was difficult to account.

Various means were adopted to regulate the rate of increase and decrease of the temperature in the oven, to exclude oxygen from contact with the baking, and the results as often misled the engineer as they helped to bring him to the desired standard process. All who have been through this will bear witness to how often they were disappointed, and how only by slow, steady, and patient investigations and collaborations of results they at length were able to deduce the conclusions which have led them to the true path which must be followed in the preparation and process of baking the raw material, from which they have seen no reason since to depart. To produce a carbon more or less dense and uniform has been the object of all, but if I have been understood, it is obvious that I attach the most importance to that process by which sufficient density and uniformity of section and surface are actually reached at this stage of the preparations of the filament.

We now have to study a stage which may be regarded as the most important with reference to the commercial use of the glow lamp. So early as 1878 it was discovered, or revealed, that in order to be able to use a large number of glow lamps on one system they must all be subject to the same electrical conditions of tension. It was found that it would be impossible to maintain uniform illumination in all the glow lamps on a system if each lamp was to be subject to different conditions of pressure ; and that the only way to achieve a practical result was to connect one terminal of all the lamps to a main conductor conveying a current in the first place sufficient for all the lamps destined to be used in the system, and in the second place having an E.M.F. or potential above zero (zero being an empirical "earth"), of an energy suitable to bring the filament to a state of incandescence ; and so arrange that the value of the E.M.F. should be the same throughout.

In other words, the system of distribution known as the parallel system was thus practically discovered. The second or return conducting path is, of course, necessary when dealing with a physical development of energy such as what we call "electricity," to complete the circuit to the so-called negative terminal of the dynamo, or other source.

It will readily be appreciated that the word "parallel" is a misnomer, the parallelism of the conductors having nothing to do with efficiency ; and that their being carried alongside of one another throughout a building only arises out of a desire to economise the labour of the workmen who have to put them up.

It would, I conceive, be well if the public, and above all the insurance companies (for it is largely a question of fire risk), could be brought to understand that the second or return wire is electrically the same as the "earth" of the electrician, and that so long as the positive, or supply wire, is well insulated and kept far apart from the negative, or return wire, no further precautions are necessary ; and when they are thus far apart, even if one is bare, greater security is obtained than by the present system, which unreasonably insulates the wire which need not be in a state of electrical tension, as well as that which is always ready to discharge. I have digressed a little way to show why absolute uniformity in the glow lamps is necessary to such a system ; nothing in its condition could be made to compensate for any defect in that respect. The chief aim, then, must be to secure this uniformity in the manufacture of the filaments of glow lamps.

(To be continued.)

THE INSTITUTION OF CIVIL ENGINEERS.

At the ordinary meeting on Tuesday, the 7th of December, Mr. Edward Woods, President, in the chair, the paper read was on "The Electric Lighthouses of Macquarie and of Tino," by Dr. JOHN HOPKINSON, F.R.S., M. Inst. C.E.

The author stated that the subject of the use of the electric light in lighthouses had been fully discussed at the Institution in 1879, when papers by Sir James Douglass, M. Inst. C.E., and by Mr. James T. Chance, Assoc. Inst. C.E., were read. The subject had been further elaborately examined by Mr. Allard, and more recently in practical experiments, made at the South Foreland, which had been exhaustively reported on by a committee of the Trinity House. The justification of the present communication was that, at the lighthouses of Macquarie and of Tino, the optical apparatus was on a larger scale than has hitherto been used for the electric arc in lighthouses, and presented certain novel features in the details of construction. In the case of both lighthouses, Messrs. Chance Brothers and Co., of Birmingham, entered into a contract for the supply of all the apparatus required, including engines, machines, conductors, lamps, optical apparatus, and lanterns. In both cases Sir James Douglass, engineer-in-chief of the Trinity House, acted as inspecting engineer to the respective Colonial and Foreign Governments.

At Macquarie there was a revolving light, giving a single flash of eight seconds' duration every minute. Owing to the altitude of the lighthouse (the focal plane being 346ft. above the sea) it was necessary to secure that a substantial quantity of light should be directed to the nearer sea ; but it was also essential that this dipping light should be but a small fraction of that sent to the horizon, otherwise its effect would be excessively dazzling. The optical apparatus was of the first order, 920 millimetre focal length, and the condensing effect was produced by a single agent ; that was, vertical straight prisms were dispensed with. Forms not differing very greatly from those introduced by Fresnel had been adopted, and were specially arranged for the purpose in hand. The upper and the lower totally reflecting prisms were forms of revolutions about a horizontal axis ; they directed the light incident upon them to the horizon and the distant sea, from 10′ above the horizon to 30′ below ; they were adjusted to distribute the light in azimuth over the arc of 3° necessary for a proper duration of flash. The refracting portion of the apparatus had the profile so calculated, that the central lens, and the three rings next to the lens above and below, directed their light to the horizon without vertical divergence, except what was due to the size of the arc ; the light for the nearer sea was obtained from the remaining ten lens-segments. From half a mile to three-quarters of a mile the sea received light from one element of the apparatus, from three-quarters to one and a quarter mile from two elements, from one and a quarter mile to two miles from three elements, from two to two and a half miles from four elements, beyond two and a half miles from six elements ; the upper and lower totally reflecting prisms came in aid at about five miles. The main power of the apparatus was hardly attained till a distance of eight or ten miles. A dioptric mirror was placed on the landward side of the arc. This mirror was arranged to form the image of the arc at one side of the carbons, so avoiding the interception of light which would result if the mirror were used in the ordinary way. Further horizontal divergence was given by the form of the lens. In the ordinary revolving light the inner face of the lens was plane, here it was cylindrical, the axis of the cylinder being vertical. The lamps were of the Serrin type, and were supplied by Baron de Meritens, who also provided two alternate-current dynamo machines, with permanent magnets. Each machine had five rings in its armature, and in each ring there were sixteen segments. In supplying one arc for a lighthouse the machine ran about 830 revolutions per minute, and gave a current of 55 amperes when half the coils were used, and of 110 amperes when the whole of the machine was in action, the internal resistance in the two cases being 0·062 and 0·031 ohm. Each machine was driven by an 8 horse-power Crossley gas engine, through a belt without counter shafting. Whilst the dynamo machines were at the works of Messrs. Chance Brothers and Co. a series of experiments had been made in March, 1881, to determine their properties. When the external resistance was a metallic conductor of small self-induction, it was found that with varying resistance and speed the currents observed agreed fairly well with calculation from the formula $\frac{A}{\sqrt{R^2+\left(\frac{2\pi\gamma}{T}\right)^2}}$ in which R was the total resistance of the circuit, γ the self-induction, and T the periodic time. When the machine was running 830 revolutions per minute $A=67$ volts and $\left(\frac{2\pi\gamma}{T}\right)^2=0{\cdot}197$ in ohms squared, hence $\gamma=6{\cdot}4\times10^5$ centimetres. The eighty sections of the machine were arranged four in series, twenty parallel. For a single section the value of γ would be 32×10^5 centimetres. The maximum induction in the core, which had an area of 5 square centimetres, was 24,600, or 4,920 per square centimetre. The loss of power was greater when the machine was doing little or no external work than when that work was great. This was clearly seen from the following table :—

Current amperes	7·70	73·60
Electrical work horse-power	0·69	5·66
Mechanical work applied	3·09	6·55
Loss	2·40	0·89

The explanation had been pointed out in the lecture by the author on "Some Points in Electric Lighting." Photometric experiments were made upon the arc, and simultaneous measurements of effective power applied and of current passing. The red light was measured through a bright copper ruby glass, and the blue through a solution of sulphate of copper and ammonia. The horse-power was measured by a transmission dynamo-

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meter; but the results must be accepted with some reserve, on account of the difficulty of ascertaining the mean tension in a strap which was constantly varying. The oscillations of the dynamometer were damped by a dash pot containing tar.

	Half Power.	Full Power.
Red candles	1,988	4,708
Blue ,,	4,079	11,382
Current (amperes)	54·5	105
Mechanical power applied (H.-P.)	4·5	6·9
Power expended in heating conducting wires (H.-P.)	0·24	0·95

The results illustrated the fact that, as the current increased, the total light increased in a higher ratio, red light in a slightly higher ratio, and blue in a ratio considerably higher. The machinery for this lighthouse was sent out to New South Wales in November, 1881. The glare of the light upon the sky was said to have been seen at a distance of over sixty miles, far beyond the distance at which it would cease to be directly visible.

The distinctive character of the Tino light was a triple flash every half minute. The apparatus for producing this effect was of the general form introduced by the author in 1874. The second order apparatus of 700 millimetre focus was adopted in this case. The horizontal divergence was obtained in exactly the same way as at Macquarie, excepting that no mirror was used. The quantity of light thrown upon the nearer sea was very much less in the case of Tino than in that of Macquarie, and greater reliance was placed upon the accuracy with which the arc could be kept in focus; experience had justified these changes as improvements of a perfectly safe nature. As there was no water upon the island, two Brown hot-air engines were supplied, each driving through a countershaft one of the machines. The countershafts could be connected by a Mather and Platt friction-coupling, so that the two machines could be driven together, or either machine from either engine. In future lighthouses, when a steam engine could not be employed, it would be preferable on every ground to use gas engines, and to manufacture on the spot either Dowson gas or ordinary gas, according to the character of the fuel available. There were two dynamo machines of exactly the same type as those supplied for Macquarie, the only novelty being in the method of using them. One of the three lamps was of larger size, for the double-power current of 200 amperes from the two machines when coupled together. This lamp was said to be suitable for a still greater current, but with about 200 amperes it soon became dangerously heated; a simple modification rendered the lamp equal to the actual work it had to do. The apparatus was delivered in November, 1884, and was put up by workmen from Messrs. Chance's workshops, under the supervision of Signor L. Luiggi, of Rome. A complete test of the performance of the light, as seen from the sea in all grades of its power, was made in April, 1885, by a commission appointed by the Italian Government. The light was well observed through rain when distant 32 nautical miles, and although below the horizon the position was precisely localised, and the triple-flash distinction unmistakable. At 18 miles distant the illumination of the flash upon white paper was sufficient to make out letters marked in pencil 1¼in. high, and when 14 miles distant it was easy to ascertain the time from a watch. The light was frequently seen at a distance of 50 miles, near to Genoa.

Some general points were dealt with at the end of the paper, and particulars were given of a plan for providing an electric lighthouse at about the same cost as a first-class oil lighthouse.

LEGAL INTELLIGENCE.

Eck, Callow and Co. v. Heath.

This was an action heard before Mr. Justice Kekewich on Friday last, in which the plaintiffs, a firm of electrical engineers and instrument-case makers, carrying on business at 11, Greville-street, Holborn, asked for a declaration of the Court that the agreement which they entered into with the defendant for a lease of the aforesaid premises for 21 years should be rescinded, on the ground of misrepresentation and concealment on the part of the defendant at the time the agreement was entered into of certain facts, which subsequently brought them into expensive litigation, and prevented them from carrying on their business.

Mr. Barber, Q.C., and Mr. Oswald appeared for the plaintiffs, the defendant being represented by Mr. Warrington, Q.C.

Mr. Barber said that the plaintiffs entered into an agreement on the 10th of April, 1885, with the defendant for a lease of the said premises for a term of 21 years, at a rental of £70, and a further sum of £50 for the use of a steam engine which was at the time on the premises. But the plaintiffs had not been long in possession when a Mr. Gardiner complained of the noise of the machinery, and on the 13th of May commenced an action against Messrs. Eck, Callow and Company. The Court on that occasion ordered that the matter in dispute should be referred to an arbitrator, and, accordingly, it was referred to a Mr. Archibald, an engineer of considerable experience. On the 4th of August of the same year the arbitrator furnished a report embodying his views as to the substance of the action, the result of which was that the plaintiffs were restrained from continuing any longer driving their engine and pumping apparatus which caused the nuisance complained of by Mr. Gardiner. The plaintiffs, when they entered into the agreement, were assured by the defendant Heath that the noise of the machinery would not be objected to by the neighbours—that, in fact, he (the defendant) had obtained the sanction of the neighbours to work it. Hence the present action, in which the plaintiffs also sought to recover damages for the loss they had sustained in consequence of the litigation which had been forced upon them.

Mr. Douglas James Callow was called and examined and cross-examined by Mr. Baker and Mr. Warrington upon the negotiations he had with the defendant before entering into the agreement, his answers substantially endorsing the foregoing statement. In the end, by the advice of the Judge, who remarked that it was one of those cases which ought never to have been brought into court, it was agreed between the parties to settle the matter amicably, each side paying its own costs, and the plaintiffs obtaining the relief they asked.

NEW COMPANY.

The Manchester Electric Supply Company (Limited) has been registered by G. Maclaren, 22, Chancery-lane, on the 3rd inst. The objects are said to be to light streets, public places, mines, ships, railways, tramways, or any other places or things by means of electricity, or other similar agency. To create or produce electricity, or other similar agency, and to supply the same for the production or transmission of power, for lighting purposes, or otherwise. According to the Memorandum of Association, the usual powers are taken as to leases and purchase. The capital of the company is £10,000, divided into 1,000 shares of £10 each.

The first subscribers are—	Share.
J. T. Chancellor, C.E., 31, Market-street, Manchester	1
W. H. Vaudrey, Solicitor, 9, St. James's-square, Manchester	1
Arthur B. Holmes, Engineer, 1, Crosshall street, Liverpool	1
J. Clough Vaudrey, Engineer, 1, Crosshall-street, Liverpool	1
J. F. Albright, Engineer, Mansion House Buildings, London	1
R. Evelyn B. Crompton, Engineer, Mansion House Buildings, London	1
Wm. A. Ryle, Engineer, Chelmsford	1

The first Directors are R. E. B. Crompton, J. F. Albright, A. B. Holmes, and J. C. Vaudrey, who are to occupy their seats for seven years from the date of registration. The qualification is £100 for each Director. By clause 3 of the Articles, Messrs. Holmes and Vaudrey are appointed managing directors, and can only be removed by the shareholders at a general meeting to be convened under table A.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Dec. 8.		Business Done Week Ending Dec. 8. Highest.	Lowest.
Anglo-American	36,	37	37½	37½
Do. Preferred	58½,	59½	60¾	59½
Do. Deferred	13½,	14½	15	14½
Brazilian Submarine	10⅞,	11⅛	11 1-16	11 15-16
Cuba	11,	11½	11⅝	11
Do. Preference	18,	19	—	—
Direct Spanish	1¾,	2¼	2	—
Do. Preference	9½,	10½	10	—
Direct United States Cable	9⅛,	9⅝	9⅝	9 3-16
Eastern Telegraph	10¼,	10½	10⅝	10⅜
Do. 6 per Cent. Preference	13¾,	14¼	14¼	13⅞
Do. 5 per Cent. Debentures, 1899	106,	109	107	—
Eastern Extension	10¾,	11	11⅛	10⅞
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	5½,	5¾	5⅝	5⅝
Do. Preference	12¼,	12½	12¾	12½
Great Northern	13⅜,	13⅝	13½	—
Indo-European	34,	35	—	—
Reuter's	7,	7½	—	—
Submarine	190,	200	198½	—
West India and Panama	⅞,	1⅛	15-16	⅞
Do. 1st Preference	8¾,	9¼	8 13-16	—
Western Brazilian	7¼,	7⅝	7¼	7
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¼,	¾	—	—
Oriental	3-16	5-16	—	—
United Telephone	13⅝,	13¾	14⅛	13¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¾,	3¼	3⅜	3¼
Do. (fully paid)	4½,	5	5	4⅝
Swan	1½,	1¾	1 13-16	1 9-16
Maxim Weston	5-16,	7-16	⅜	—

MISCELLANEOUS.

Telegraph Construction	39	40	40½	39½
India Rubber, Gutta Percha, and Telegraph Works	24	25	24½	—

TRAFFIC RECEIPTS FOR NOVEMBER, 1886.

Companies.	Nov., 1886.	Nov., 1885.	Increase.	Decrease.
Cuba Submarine	2,550	2,313	237	—
Direct Spanish Telegraph	1,860	2,032	—	172
Eastern Extension	36,729	40,427	—	3,698
Eastern Telegraph	50,817	56,245	—	5,428
Great Northern	21,200	—	—	—
West Coast of America	4,190	—	—	—

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NOTES.

CABLE REPAIRED.—The cable between Trinidad and Demerara has been repaired.

CABLE INTERRUPTED.—The cable between Guernsey and Alderney is interrupted.

OLDHAM.—The Corporation of Oldham have decided to light the Town Hall, the Municipal Picture Gallery, and the School of Art and Science with electric light.

PERSONAL.—We are informed that Mr. Bernard Drake, of the firm of Drake and Gorham, 2, Prince's Mansions, Victoria-street, S.W., has been appointed electrical engineer to the Bank of England.

AWFUL!—An American inventor, who has been devoting his attention to electric railways, has recently mentioned that he has now nearly *two thousand* claims pending before the United States Patent Office.

NEW CABLE SHIP.—Messrs. Thompson and Son, of Sunderland, are about to launch a cable ship of 200 horse-power, which has been built to the order of a firm at Milan. She is 250ft. in length, carries three cable tanks, and is lit throughout by electricity.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending December 10th were £3,665, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

COLONIAL CONFERENCE.—The Secretary of State for the Colonies has proposed that a Colonial Conference shall be held in London early in 1887, when among other things the delegates would consider the whole question of postal and telegraphic communication with our colonies.

TELEPHONIC "TOLL" LINES IN THE STATES.—It is stated that the American exchanges which have introduced the "toll" system on any large scale find that it pays them well to cultivate this class of business, as these lines have a far lower ratio of expense to earnings than is the case for ordinary exchange lines.

BRADFORD.—During the late bazaar at St. George's Hall, Bradford, the buildings were lit with arc and incandescent lamps by the Woodhouse and Rawson Electric Contract and Maintenance Company (Limited), of Lancashire, Yorkshire, and Cheshire. A very good effect was obtained by 30 lamps which were used for lighting a Christmas tree.

TO PERSONS ENGAGED IN THE ELECTRO-PLATING INDUSTRY.—We are requested to state that at Prof. S. P Thompson's lecture at Finsbury Technical College, on Thursday, December 23rd, on "Dynamo Machines for Electro-Plating," free admission will be given to any person engaged in the electro-plating industry who will apply beforehand for a ticket of admission.

THE TELEPHONE IN BELGIUM.—We have received a copy of "La Téléphone Privée en Belgique," by M. Charles Mourlon, a book of fifty pages, containing very numerous illustrations, and giving a very complete account of the rise and progress of telephony in Belgium—more especially in connection with private lines, which are very numerous in some of the manufacturing towns of the country.

TELEPHONING OPERA AT LISBON.—The Lisbon Telephone Exchange have recently made arrangements by which their subscribers, for certain extra payments, are "put through" to the San Carlo Theatre, and are thus enabled to listen to the opera from their own residences. Special precautions are taken to secure the most perfect transmission, and the results have proved highly satisfactory.

TEMPORARY INSTALLATION.—On the occasion of a bazaar held on the 8th inst., at the Town Hall, Saffron Walden, the building was lighted by 30 Woodhouse and Rawson 16 candle-power 50-volt lamps. The current was supplied from an Elwell-Parker dynamo, driven by a twin-cylinder portable engine placed in a yard near by. The arrangements were carried out by Mr. Arthur Barrett, electrical engineer, of Saffron Walden.

FACTORY LIGHTING AT LONDONDERRY. — Mr. A. W. Richardson, of the Anglo-American Electric Light and Engineering Works, Stretford-road, Manchester, has recently completed an installation of 80 twenty candle-power incandescent lamps in the laundry department of Messrs. Welsh, Margetson's shirt factory, Londonderry. A "Richardson" dynamo, H type compound-wound, is employed, giving 110 volts and 55 amperes, at a speed of 440 revolutions per minute.

ELECTRIC CLOCKS IN VENEZUELA.—An export house in Stuttgart has just supplied to the town of Caracas, in Venezuela, a number of clocks for the public streets. On account of frequent earthquakes, clock towers are not advisable, and since the clocks must be placed low, a comparatively large number is required. Among the clocks sent out is one with a dial 13ft. in diameter. All the clocks will be worked electrically, and illuminated at night with the electric light.—*Industries.*

THE GREAT STORM.—Although the highest wind velocity recorded in the United States during the recent storm did not exceed forty miles an hour (while on its arrival in this country some of the gusts had attained a velocity upwards of 50 per cent. higher), yet very great damage is reported to have been caused to the telegraph wires in the Eastern States. In New York local communication was entirely disorganised. It is, however, believed that many of the wires were not broken by the wind but by the remarkably heavy rain which fell during the storm.

"THE NEW YORK HERALD."—According to an American journal, although Mr. James Gordon Bennett has been absent from the States for several years, he yet continues to perform the actual work of editor-in-chief of the *New York Herald.* Every morning, in whatever part of Europe he may happen to be, so long as a telegraph office is within reach, his second in command cables from New York a complete summary of the news of the previous twenty-four hours. Mr. Bennett then cables his comments, opinions, instructions, or advice. This service is said to cost—or at least to be worth—about £25,000 a year.

A CHURCH STRUCK BY GLOBULAR LIGHTNING—During the severe storms of last week at the village of Bradninch, Devonshire, the church tower was struck by lightning. Very serious damage was done, the tower being shaken to its foundation and cracked throughout one-third of its length; one of the pinnacles fell through the roof, and stones from the top of the tower were hurled through cottage windows at a considerable distance. This case is an interesting one, as from the description of an eye witness there can be no doubt that the destruction was due to a discharge of globe lightning. Balls of fire are described as whirling around the summit of the tower for a second or two, and disappearing with a tremendous explosion.

A NEW TERM REQUIRED.—No very satisfactory term exists at present by which to distinguish in a dynamo the diameter of the space between the pole-pieces *minus* the diametrical cross-section of the iron in the armature. Upon the suggestion of M. Cabonellas, the French have recently adopted the phrase

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entre-fer for this purpose, and nothing better could be wished for; it is unfortunate that a literal translation does not suit our tongue, nor is "intraferal space" much better. The expression "air space," which is often used, is not only inexact, but is liable to lead to confusion with the mechanical "clearance." If, however, "air-space" is permissible at all, why not use "diamagnetic space," which is at least equally exact and not so liable to lead to confusion ?

THE POSTAL TELEGRAPH SERVICE.—On Tuesday evening a meeting of the Exeter telegraph clerks was held for the purpose of considering the evidence that would be required by the executive committee to lay before the Royal commission of inquiry into the working of the Civil Service. It was stated Mr. Fawcett's scheme, although intended to have greatly benefited telegraph clerks, had practically failed, through the retention of the system of classification and from the greater portion of the higher appointments being given to the postal branch. A committee was appointed to obtain accurate statistics from the surveyor. Resolutions were passed to the effect that every legitimate means should be used to obtain a full inquiry into the many grievances of which the clerks had to complain.

AN ELECTRIC LOW-WATER ALARM.—An electric low-water alarm, based upon a very simple principle, has recently been described before the American Institute. The apparatus consists of two gauge-cocks, a water gauge, a mercurial thermometer, a couple of Leclanché cells, and an electric bell. Two wires are inserted in the thermometer tube, and are connected with the battery and the bell. As the water in the boiler gradually lessens, steam comes down through the upper arm and gauge glass, and when a certain level is reached it enters also through the lower arm. Being hotter than the water, the increased temperature of the steam expands the mercury in the tube and closes the circuit. The bell then continues to ring until sufficient feed-water has been supplied; the feed-water being cooler, the mercury contracts, the circuit is broken, and the alarm ceases.

THE BRITISH ASSOCIATION.—A final meeting of the local executive committee was held at Birmingham on Wednesday, the Mayor (Alderman Martineau) in the chair. Reports were received from the exhibition sub-committee and from the local officers, from which it appeared that the exhibition yielded a surplus of £5,200. After defraying out of this sum all expenses connected with the meeting of the association in Birmingham, there remained an available surplus of £1,311. 1s. 5s. It was resolved that this sum be devoted to the provision of a permanent record of the meeting of the association in Birmingham, and of the exhibition to which it gave rise, by the purchase of a collection of illustrations of art in the Birmingham metal work exhibition at Bingley Hall, to be placed in the museum and art gallery, and that a select committee be appointed to make the necessary purchases.

UNDERGROUND WORK IN THE STATES.—At Boston the Telephone Company has commenced putting its wires underground of its own free will. A conduit to take 600 wires has been laid along some of the principal routes. The system adopted is that of creosoted wood troughs, together with a protecting coating upon the cables themselves, consisting of lead, alloyed with a little tin. This is the plan which has so far given very favourable results at Brooklyn, where it has now been in use for over two years. When the work at present contemplated by the Boston Company has been completed, some of their lines will run underground for a continuous length of over three miles. This is, we believe, a greater distance than any hitherto undertaken for similar lines on exchange service. It is to be hoped that the results will prove to be satisfactory. It may be added that by the end of the year over 1,500 miles of underground cable will have been laid in Boston.

TELEGRAPHS IN CHINA.—During the hostilities with France in 1884, the Celestial Government appears to have become aware for the first time of the fact that by the aid of the telegraph it is possible for a central administration to keep a much firmer control over provincial authorities. This fundamental fact having once been realised, the authorities are busily engaged in extending lines in all directions between Pekin and the great provincial towns. The material is all bought either in this country or in Denmark, but the work of construction is carried out almost entirely by the Chinese themselves. The first lines were built by Danish engineers and workmen, but the Chinese proved themselves such apt pupils, that in a very short time they felt competent to dispense with the aid of the Danes. It may be hoped that the manifold advantages of telegraphs will become so evident to the Chinese as not only to induce them to extend the wires throughout their vast and populous Empire, but also to pay some little more attention than they have ever yet done to the many other little dodges which outer barbarians would be only too pleased to put them up to.

TELEGRAPHS IN QUEENSLAND.—We have received the Report of the Post and Telegraph Department of Queensland for the year 1885. The number of telegraph offices in operation at the close of the year was 259, of which 36 had been established during the previous twelve months; 12,608 miles of wire, and 7,537 miles of posts had been erected, while 3,006 miles of wire and 1,567 miles of posts were in course of construction. The gross revenue amounted to £99,980, and the total expenditure to £92,932. The expenditure for maintenance and repairs of lines during the year amounted to £5,480. The total amount expended in construction of lines up to the end of last year amounted to £599,453. Iron poles are very largely employed, and give great satisfaction; in certain districts they are frequently bent by the force of the gales, but it is stated that they can be straightened again without difficulty. In October last quadruplex working was established between Brisbane and Sydney, and another quadruplex line will shortly be worked to Bowen. Two or three lines are also working duplex. The Department has established four telephone exchanges, of which Brisbane has 356 subscribers, and the others about 50 each.

MOTORS FOR PASSENGER LIFTS.—The use of the hydraulic system for working passenger lifts has given such excellent results in practice, and has so much to recommend it on the score of safety and trustworthiness, that it would scarcely be wise to recommend its replacement by purely electrical methods. But although the lifting force may still be obtained by water-power, there is no doubt that in future, whenever the distribution of power by electricity shall have become an accomplished fact, electromotors will be very largely employed for raising water for this and other purposes wherever the required pressure is not obtained directly from the water mains. The ability to dispense with the steam or gas engine, at present required for this purpose, would undoubtedly lead to an enormous increase in the employment of these convenient appliances. When once the required current is available, all the arrangements can easily be made absolutely automatic. The motor can be set to fill the tanks to a required height, then to automatically stop running until the water has fallen to a certain level, and then again coming into action. A similar arrangement is already

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in use in some of the American cities, and works with perfect success.

"THE PEACEMAKER."—One of the most striking illustrations of the uses of electricity in modern naval warfare is to be found in the submarine boat which has recently attracted much attention in New York Harbour, and which has been christened "The Peacemaker." Originally the intention was propel the boat by electricity, but the trials are said to have been not altogether satisfactory, and soda motors have for the present been substituted. The fault, in all probability, lay with the accumulators, and we have little doubt that eventually electricity will be found to be perfectly adapted for the purpose. In the meantime the boat is of course lit throughout by incandescant lamps, and provided with means for firing torpedoes by electricity. The special novelty in the electric arrangements consists in the device whereby the torpedoes are attached to the keel of the ship which is to be destroyed. Two torpedoes are connected to the same cable, through which also four insulated wires are led within the boat. The current passing through one pair of wires traverses the coils of a powerful electro-magnet whose poles are outside the shell of the torpedo. A cork float around the same end causes the apparatus to tend to float with the poles upwards. Thus on diving underneath a hostile vessel, the torpedoes, being liberated, immediately rise upward and grip the iron keel; they can then be fired from a safe distance by means of the second pair of wires. A false wooden keel would, however, considerably diminish the terrors of this formidable weapon.

CHARGE OF ELECTRIC LIGHT APPARATUS IN HER MAJESTY'S SHIPS.—The following alterations are to be made in the Queen's Regulations with respect to the charge of electric light apparatus in Her Majesty's ships: The electric light apparatus, so far as regards the lamps, projectors, and conducting wires, is for store purposes in charge of the gunner, or the officer in charge of gunner's stores, except in troop or other ships which bear neither torpedo ratings nor gunner; in these ships the engineer officer is to have charge of the whole of the electric light apparatus and stores. The dynamos, and engines for driving them, are in charge of the engineer officer, who is responsible for their mechanical and electrical efficiency. The torpedo officer is to be responsible for the efficiency of all electrical circuits outside dynamo terminals, and for the management of the internal, search, yard arm, and other electric lights; but in ships where there are torpedo ratings, and no torpedo officer, the captain is to nominate the fittest person to perform the above duty from officers who have gone through a lieutenant's short course, or sub-lieutenant's course in the torpedo school. The search lights should be frequently exercised to instruct the officers and men in their capabilities for defence against torpedo boats, directing the fire of guns, and signalling purposes, under the direction of the torpedo officer or the officer nominated, and the particulars of such exercises are to be inserted in the half-yearly report of torpedo practice.

THE COST OF ARC LIGHTING.—On Friday evening last a lecture was delivered in the Royal Institution of South Wales before the Swansea Scientific Society by Mr. Polyblank, foreman of the Swansea Harbour Trust Works. In the course of his address Mr. Polyblank quoted the following figures as representing the actual working cost of an arc lighting installation at the works of Messrs. Kitson, the well-known locomotive engineers of Leeds. The installation consists of a No. 7 Brush dynamo supplying twelve arcs and a No. 5 machine supplying six arcs, the armatures being of the obsolete type. Each machine is coupled direct to a Parsons high-speed engine; these have now been running for over five years at an extremely small cost for repairs—in fact, all that has been done to them has been to let up the crank-pin bearings once a year. The repairs to the dynamos have been of an equally negligible character, and only one pair of brushes has been used per annum. There is no vibration when running, and no foundations were put in. The plant is in charge of a labourer, who supplies the oil required once a day, and has practically nothing further to do. As to the cost, using positive carbons at 3d. per foot and negative carbons at 1½d. per foot, in 16 hours 2ft. of positive and 1ft. 2in. of negative are consumed. This makes the cost of carbons per lamp per hour 0·48d., the boiler evaporates 9lb. per lb. of coal at 6s. per ton, and the Parsons direct acting engines use 40lb. to 50lb. of steam to the actual horse-power; this brings the cost of fuel to 0·16d. per lamp per hour. The oil used per 8 hours run in the two engines is two pints at 2s. 6d. per gallon, the water costs 6d. per 1,000 gallons, and the attendant gets 18s. per week. Summing up the working expenses on the above basis we get for a 60-light installation:—carbons, 0·48d.; fuel, 0·16d.; water, 0·03d.; oil, 0·09d.; attendant and repairs, 0·24d.; a total of 1d. per lamp per hour for working expenses. Messrs. Kitson, in making the comparison between the economy of electric light over gas, state that in Leeds gas costs 1s. 10d. per 1,000 cubic feet, No. 3 burners being generally used at the works, which are said to give 16-candle light and to use 3 cubic feet per hour; it therefore requires 125 burners to give the same light as one arc lamp, and adding one-sixteenth for rent of meter, the result is a working cost of 8¾d. per hour for gas to give the same light as afforded by one electric lamp.

ARAGO.—Next year being the centenary of the birth of François Arago, a movement has been set on foot in France for the purpose of raising a national subscription to erect a statue to his memory. It is proposed to place the statue in the centre of the large open space outside the Paris Observatory, and M. le Contre-Amiral Mouchez, director of the Observatory, has been appointed president of the committee which has taken the work in hand. In France Arago is honoured not merely as a *savant* but equally as a statesman and a patriot. He was undoubtedly a man of wide sympathies, possessing, at the same time, in an eminent degree, that quality of solid practical wisdom which is not always conspicuous in the French character. By an exceptional suspension of their rules Arago was made a member of the Académie des Sciences at the age of 23. This distinction was conferred upon him on his return from a geodesic mission in Spain and the Balearic Isles, where he had been absent three years, and which had yielded results of the highest importance to our knowledge of the figure of the earth. In 1830 he was appointed permanent secretary to the Academy. In this capacity he displayed a singular unselfishness and enthusiasm in assisting to the utmost of his power to further the labours of other workers in the field of science, and his correspondence extended to almost every man of any claim to scientific distinction in Europe. In the early days of telegraphy he vigorously and successfully protested from his seat in the Chamber of Deputies against the intention of the Government to prohibit the employment of the electric telegraph in France, except for State purposes. The French are fond of claiming for him an important share in the discovery of the principles upon which the telegraph was shown to be a practicable idea—but this claim is of a somewhat shadowy character. As an electrician his name is most widely known in connection with the experiment which led to the discovery of the "damping" action of a copper disc upon the vibrations of a magnetised needle, and for which an explanation was afterwards found by Faraday. Hence Arago

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has probably a prior claim to stand sponsor to that troublesome and useless phenomena of induction which is now attached to the name of Foucault. Faraday's title being, however, equally good, clearly the phenomenon should have been christened the Farrago. Arago was for a long period President of the Municipal Council of Paris, and exerted himself on behalf of numerous measures for the amelioration of the moral and physical condition of the lower quarters of the town. At his suggestion the *Proceedings* of the Academy were first made public, and the *Comptes Rendus* was commenced. After the revolution of 1848, he became a member of the Provisional Government, as the Minister of War and Marine. During his short term of office he secured the abolition of slavery in the French Colonies and of corporal punishment in the fleet. Refusing to take the oath of allegiance to the second Napoleon, he lost almost his entire fortune, and was exiled from his native land. In 1853 he died. It is well that his memory should be cherished in the France of to-day.

ELECTRICITY FOR THERAPEUTICAL PURPOSES.—The following paragraph appears in the *Hampshire Telegraph* for December 11. We trust that our readers will not neglect to read it from beginning to end, for it is much too good to be lost. The "heavily charged" reporter discovering that he could still sit down and even read and write "without the slightest inconvenience" while sublimely conscious of the fact that he was "renewing vitality" is a really touching picture:—"The public of Portsmouth and vicinity are indebted to Captain Arthur Byng for placing electricity, for the alleviation and cure of all kinds of nervous diseases, easily, cheaply, and safely within their reach. We understand that Captain Byng has made this science a special study for some years past, and he has, after numerous experiments, fitted rooms with appliances that will enable electricity to be taken with perfect ease by any number of people at the same time. The rooms are situated at 23, Landport-terrace, and being quite close to the King's-road Tramway Junction they are easy accessible from all parts of the borough. They are comfortably furnished, and are situated on the ground floor so as to be on a level with the street and obviate the climbing of stairs. From a personal inspection we are enabled to speak of the complete success attending the various methods by which electricity is administered. There is no occasion to take off even outside wraps, and the current may be taken either sitting or standing. A number of regulators are placed in the room, which are worked with the utmost ease and accuracy by the patients themselves, so that they actually regulate the force of the current themselves and take it any strength they like. They are also enabled to instantaneously diminish the strength of the current as they wish. Captain Byng claims no new method of generating electricity, as his patent applies only to a new method—subdividing the current so as disseminate it equally throughout a room and administer it in various strengths to individuals sitting in that room. The positive and negative poles of a large coil are placed in connection with an insulated floor and an insulated ceiling, the floor consisting of sheet metal, and the ceiling consisting of wires broken by steel points, so that anybody placed on the floor of the room by that simple act is actually between the poles, and thus becomes charged with the electric fluid. Although heavily charged our representative ascertained that he could sit, read, write, or do any of the ordinary requirements of business without the slightest inconvenience, thus renewing vitality at the expense of no bodily labour. The medical men of Portsmouth, we may assume, will not be slow to appreciate the benefits thus placed within reach of a very large proportion of their patients, at whose disposal the rooms are now placed at most reasonable charges. We understand that the electrical rooms will be worked by a company of which Mr. J. Y. Martyr is the secretary, to whom the public should apply for all information. The rooms are to be opened from ten till four, and patients will be charged from one shilling to five shillings, according to the treatment they receive and the length of time they remain in the electrical room. On Tuesdays and Fridays it is intended to open the room from seven to nine p.m. for the benefit of the poorer classes."

ENGLISH *v.* AMERICAN DYNAMOS.—Some little time ago a contemporary journal, referring to a paper by Mr. Crompton which was published in *Industries*, made the remark that "at the present moment the most perfect incandescent light dynamos are produced in England; although as regards arc-lighters, we are in fairness bound to admit the superiority of the American designs." These views, which would probably be endorsed by most English electricians, do not, however, find favour with our friends across the Atlantic, and what is more serious they are prepared to bring facts—or at least figures, which after all is not quite the same thing—to support their own opinions. "So far as this statement (above quoted) refers to arc machines we are willing to accept it as true," says one of the American journals. But having given this proof of magnanimity they are confident that the remaining assertion can be "entirely refuted." The writer then institutes a comparison between the efficiencies claimed for certain English machines and those of the Weston and Edison machines, as determined by the tests at the Franklin Institute. It will be remembered that four Edison and three Weston machines were tested by the Institute in the autumn of last year, and undoubtedly these tests are among the most important on record. Our contemporary, however, proceeds with the comparison as follows:—"At full load the seven machines showed an average efficiency of 95·6 per cent., the lowest efficiency for any single machine being 94·45 per cent. Comparing the five best machines of different makers given in Mr. Crompton's table, we find their average efficiency to be only 93·4 per cent." At this point we must beg leave to enter a demurrer. Eight English machines are given in Mr. Crompton's table, including a small one, having an electrical efficiency of only 78 per cent. Had this last machine been included the average efficiency might have been induced to come down about 87 per cent. Although our contemporary has honourably declined to take full advantage of this opportunity, still we would submit that there is no reason whatever why five machines should be selected any more than four or three, especially as an efficiency of only 90 per cent. is claimed for the fifth machine. So far as a comparison of this sort can be made fair (or useful) at all, it will manifestly be fairest to select two machines by leading English makers for comparison with the two American types. Here the tables are turned, and we claim (at least an apparent) superiority of no less than 0·4 per cent.—the efficiency of the two English machines being each entered at 96 per cent. If it were worth while to pursue the subject further, we might point out upon the one hand that the highest of the tests of the American machines is marked "unofficial" by the Institute, while upon the other hand the English figures are slightly discounted by the fact that the output of the dynamos in question is in each case somewhat higher than that of the American machines. But at the best a comparison of results taken with machines of different sizes, at different dates, under different methods, and by different people, cannot possibly afford room for the discussion of ratios differing less than one per cent., so that the whole argument is in reality futile. While, however,

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we are ready to admit that the practical superiority of English built machines is to some extent an open question, there can, we think, be no question whatever as to which country has advanced furthest in the *science* of the dynamo.

THE ELECTRC LIGHTING OF RAILWAY CARRIAGES.—We are very pleased to see that the *Pall Mall Gazette* maintains its championship of the cause of the better lighting of railway trains with praiseworthy energy. A representative of the journal has recently interviewed the managers of several of the leading lines, and has investigated the arrangements adopted for lighting carriages with gas on the Pintsch system. This method has for some time been employed on the Metropolitan Railway; but, though far superior to oil, cannot, of course, compare with electric lighting. Mr. Scotter, the general manager of the South Western Railway, expressed himself strongly in favour of electric light (with which the South Western Railway has already obtained an extensive acquaintance for yard and station lighting, both with arc and incandescent lamps), but he considered that the cost was as yet too great for general use. The following is the account given by the *Pall Mall* of their interview with the general manager of the London, Brighton, and South Coast Railway:—"We all acknowledge that the lighting of our trains is not what it ought to be, confessed Mr. Allen Searle, the secretary and general manager, but the directorate have determined that something shall be done without delay toward the removal of the reproach. On the 1st January a great experiment will be begun in the illumination of twelve selected trains. Six of these will be lighted with oil under new conditions; and the other six will be illuminated by electric lamps. The oil lamps will be filled with colza oil carefully selected, and fitted with wicks of the best quality; the glass will be clear and kept well polished, and reflectors of a new pattern will be introduced. On the electrically lighted trains each compartment will be provided with one light of ten candle-power, and where two compartments are structurally one, care will be taken to dispose the lamps in a way which will avoid shadows. The electricity will be generated by the locomotive drawing the train. The resolution to try the six trains electrically lighted is the outcome of experiments which Mr. Stroudley, the locomotive superintendent, and Mr. Houghton, the electrician of the company, have conducted for two years past with a train running on the Crystal Palace and Croydon lines. The results of the lighting of the Pullman trains running between the metropolis and Brighton confirmed the directorate in its determination. The system of lighting by oil lamps cost £70 per train per annum. It is estimated that the lighting by electric lamps will entail an expenditure of £100 per train per annum, but it is hoped that the actual cost will fall below that. The electrical system thus experimentally adopted by the London and Brighton Company is, we believe, that of the Railway Electrical Contractors (Limited). In this company's plan the dynamo is driven from the axle of the guard's van by the momentum of the train and fills the accumulators while the train is in motion, and there is thus always sufficient light stored for the very longest stoppage. The whole apparatus is enclosed in a locked cupboard on one side of the guard's van, is quite automatic, requiring no care or attention, except now and then when one of the company's officers sees that the machinery is oiled. It was of this system that Mr. H. C. Calcraft, the assistant secretary of the Railway Department of the Board of Trade, wrote at the close of 1884: 'As far as I could judge, the problem of lighting trains by electricity which is generated by the momentum of the train itself appears to have been solved.'"

THE ISLE OF MAY ELECTRIC LIGHTHOUSE.—The electric light has just been formally installed at the Isle of May lighthouse. The power of the beam of light from the paraffin flame previously in use was equal to 9,500 candles, while that of the electric light now shown is equal to about 30,000 candles, or more than three times that of the intensity of the paraffin light, and can, if desired, be increased to 60,000 candles during fog. This beam of light is one of the most intense ever shown from any lighthouse, as all the latest improvements, not only in the electric but in the optical apparatus, have been combined at the Isle of May. The preparations, consisting of buildings, dioptric apparatus, steam engines, and other appliances in connection with the introduction of the electric light at the May, have been in progress during the past eighteen months, according to the designs and under the superintendence of Messrs. Stevenson. The buildings, which have now been completed by Messrs. Stratton, contractors, Edinburgh, consist of dwellings for the engineer and two additional keepers, an engine and boiler house, workshop, coal store, and other necessary erections. In the engine house there are two steam engines for driving the electric machines, each of 16 horse-power, made by Messrs. Umpherston, Leith. There are also in the engine room two electrical machines supplied by Baron de Meritens, Paris. Only one engine and one electric machine are as a rule used at a time; the spare engine and machine are provided to guard against accident, and unless when very foggy weather occurs, it will not be necessary to use the full power of both engines and electric machines. The electric machines are "alternate current" magneto-electric machines of the largest size hitherto made. The armature is driven by a belt from the engine, through a countershaft, at a speed of 600 revolutions per minute. The current is conveyed to the lighthouse tower, situate at a distance of 880ft., by copper rods 1in. diameter. These rods or conductors are placed in a groove, in a low wall of cement rubble concrete, which has been built between the engine house and the tower, and alongside of which a pathway has been formed. The engine house and tower are also placed in communication by telephone. The conductors are led up the tower to the lamps inside the dioptric apparatus. The electric lamps are of the most improved kind, one being always in its place inside the dioptric apparatus, while another is ready, with the carbons adjusted to the correect height, to be shunted into the focus of the apparatus when required. The carbons are 1½in. diameter, and have a small core of pure graphite running through the centre. These carbons are found to burn with great steadiness and regularity. It was originally intended to use continuous current electrical machines, but unlooked-for difficulties were experienced in constructing an arc lamp which could be relied on, and recourse was had to the alternate current machines of Baron de Meritens, as above mentioned. The dioptric apparatus is of a novel description, on the condensing principle so successfully introduced into the Scottish lighthouses by Messrs. Stevenson thirty years ago, and since then largely adopted in other lighthouses. The May apparatus is so designed as to give a group of four flashes in quick succession, with intervals of darkness for thirty seconds, and condenses the light which would spread over 45deg. into 3deg. or fifteen times. The apparatus has also been arranged to admit of the beams of light being dipped to show near the lighthouse during dense fog, instead of being sent to the horizon. The condensing prisms circulate round the central apparatus by means of a machine driven by a falling weight. The dioptric apparatus was made by Messrs. Chance and Co., of Birmingham, and the revolving machine by Messrs. Milne, of Edinburgh, both from the designs of Messrs. Stevenson.

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 98.)

Since a flat coil of wire conveying a current behaves in all respects like a magnetic shell, having a south pole upon one face and a north pole upon the other, it follows that such a coil will be subject to the directive action of the earth, or of any other magnet, and will also be attracted by a magnet. Thus, if the north pole of a magnet be brought near to such a coil which is free to move, the coil will turn until its south face is presented to the magnet pole, and will then approach the magnet. The coil will come to rest finally in the plane of the magnet's equator.

Fig. 7 shows the lines of force, as depicted by iron filings, due to a coil conveying a current and a magnetic pole which are attracting one another. Fig. 8 shows the lines of force when the current is reversed, so that the pole and coil repel one another. By remembering that there is tension along the lines of force and pressure perpendicular to them we can tell from the pictures the nature of the mechanical action.

Fig. 7.

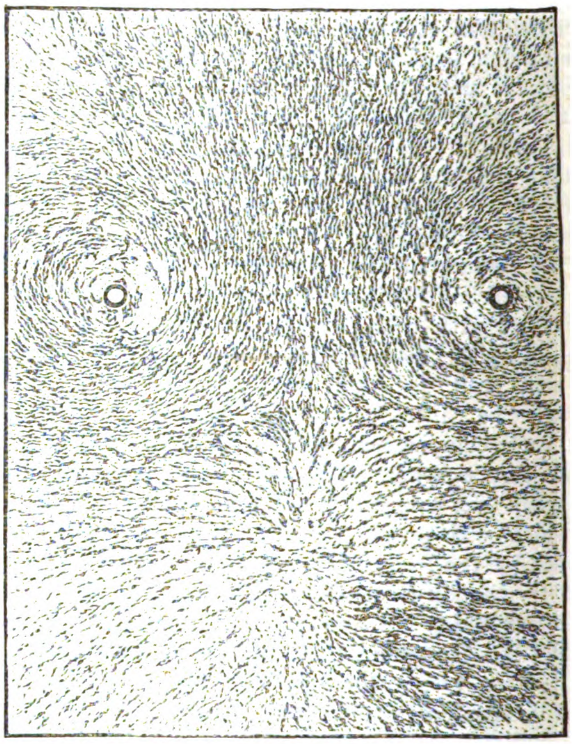

Fig. 8.

Def. The *positive direction* through a circuit conveying a current is the direction in which a right-handed screw would advance if rotating with the current.

A circuit conveying a current will tend to set itself in a magnetic field, so that the greatest possible number of lines of force pass through it in the positive direction.

In obedience to the same law magnets free to move in the neighbourhood of a current will tend to set themselves so that the greatest possible number of lines of force due to the magnets may pass in the positive direction through the circuit.

If the lines of force pass through the circuit in the negative direction the tendency will be to diminish their number, and, if possible, to reverse them.

This is the fundamental law of electro-magnetic action, and enables us to predict the behaviour of any wire conveying a current, if it is free to move in the presence of magnets or of other currents. The wire must form either a portion of a circuit or a complete circuit. In either case it will move so as to increase the number of lines of force passing through the circuit in the positive direction. If it is a straight wire of unlimited length which we are considering, we may suppose the circuit closed on either side of the wire, and the result will be the same. Hence it follows from the above law that parallel wires conveying currents in the same direction attract each other, and repel each other when they convey currents in opposite directions. A closed circuit will turn itself so as to cause as many as possible of the lines of force to pass through it in the positive direction, and will at the same time move towards the strongest part of the field for the same reason. In a uniform field a plane closed circuit will turn until its plane is perpendicular to the lines of magnetic force. Thus, under the action of the earth a coil in which a current is flowing will, if free to move, set itself with the axis of the coil parallel to the direction of the dip needle. A coil so suspended would serve as a compass and dip circle combined.

A very complete experimental investigation of the action of wires of various forms, conveying currents, upon one another and upon magnets was made by Ampère.

From what has been said it appears that a coil of wire, or solenoid, conveying a current behaves in all respects like a magnet upon bodies outside it. But the lines of force due to a coil are closed curves embracing the coil, and a needle suspended within the coil will set in the opposite direction to that taken up by a needle outside the coil. If, however, we employ a tubular magnet, and suspend a magnetic needle within the tube it will point in the same direction as a needle outside the tube and near its equator—that is to say, the north pole of the needle will point towards the south pole of the large magnet. In the magnet, as in the coil, the lines of force are closed curves passing from the north pole to the south pole through the air, but in the case of the magnet they return *within the substance of the steel.* Inside the tube the lines of force proceed as in the air outside the magnet.

On account of the similarity in the behaviour of a coil conveying a current and of a magnet, Ampère supposed that magnetism was due to electric currents flowing permanently around the molecules of the magnet. In a piece of unmagnetised iron or steel he supposes that the planes of these currents were arranged in all directions, so that the several molecules neutralised one another's action, and that the operation of magnetisation consisted in compelling the molecules to turn with their currents parallel to one another, the planes of these currents being perpendicular to the axis of magnetisation. In magnets which are not magnetised to the highest degree conceivable, the planes of the currents are not all

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parallel, but have simply a tendency towards one direction. In the case of a solid bar magnet the molecular currents will neutralise one another at all points within the bar, and the effect will be the same as if a current flowed round the circumference of the bar. In the case of a tube the system will be equivalent to two equal currents flowing in opposite directions, one over the outer surface and the other over the inner surface of the tube. This will account for the behaviour of such a tube at all points, whether within or without the tube. Ampère supposed that the molecular currents experience no resistance, and thus when once set up continue permanently without requiring any source of energy for their maintenance. The theory does not explain why iron should lose all its magnetic properties at a bright red heat.

It has been stated that when a current flows through a coil of wire, magnetic lines of force will pass through the interior of the coil in the positive direction. If a bar of iron be placed within the coil the lines of force will enter the bar at one end, and, passing through the iron in preference to the air, will diverge from the other end of the bar. The end at which the lines enter will thus form a south pole, and that from which they diverge will form a north pole, the iron becoming a magnet by induction. If a steel bar be employed instead of an iron bar the induced magnetism will not be so strong, but the bar will retain its magnetism after the current has ceased. If the current be suddenly started and stopped a few times in succession, a steel bar placed within the coil may be permanently and strongly magnetised.

An electromagnet is a bar of soft iron surrounded by coils of wire. The bar is generally constructed so as to form three sides of a rectangle, in order to diminish the extent of the magnetic field formed in the air between the poles of the magnet.

The discovery by Davy and Arago of the temporary magnetisation of a soft iron bar by an electric current rendered possible a number of contrivances of the nature of electromagnetic engines. The most familiar of these is the common electric bell. Here an iron armature is attached to the electromagnet, but, in running towards it, breaks the circuit of the exciting current, thus destroying the magnetism when the armature is withdrawn by a spring, provided for that purpose, until by its return it again closes the circuit and excites the magnet. In all the electromotors of this class an iron armature is attracted by a magnet while moving towards its poles, but ceases to be attracted when it is receding. In this way work is done upon the armature while approaching the magnet, and is not absorbed again in its return. Continuous circular motion may be obtained by attaching iron armatures to a wheel, which as it revolves will carry them past the poles of the electromagnet, and by connecting a contact breaker with the wheel, so arranged that the magnet may be excited when one of the armatures is approaching its poles, but may cease to be a magnet when the armature begins to recede. Sometimes two magnets are employed, and armatures made to alternately approach and recede from their poles while the reciprocating motion is converted into continuous circular motion by cranks or equivalent contrivances. All the motors of this class are, however, very *inefficient*, and waste by far the greater part of the energy expended by the battery upon them. A better motor, somewhat resembling those just described, is made in small sizes by Mr. Apps. It consists of two small electromagnets, one of which is fixed while the other can rotate about an axis parallel to its cores and midway between them. The same axis is similarly situated with respect to the fixed magnet, and twice in each revolution the movable magnet has its poles just opposite those of the fixed magnet and within a small fraction of an inch from them. A commutator is connected with the rotating magnet and reverses the current in that magnet, so that when its poles are approaching those of the fixed magnet there is attraction between them, but when they are receding there is repulsion.

But it was Faraday's discovery of the tendency of a wire conveying a current to move across lines of magnetic force which led to the construction of the most efficient electromotors. Generally these instruments consist of an "armature," containing coils of wire, which is free to rotate in the strong magnetic field between the poles of a horse-shoe magnet. Sometimes iron is introduced into the centre of the armature, in order to concentrate the magnetic force. When a current passes round a coil in the armature this coil moves so as to place its plane at right angles to the lines of magnetic force, that the greatest possible number of these lines may pass through it in the positive direction. No sooner does it reach this position of equilibrium than the current in it ceases, and the energy of motion of the armature, as well as the action of the other coils, carries it over this "dead-point." Shortly afterwards the commutator, which is connected to the revolving armature, sends a current round the coil in the opposite direction to the first current, and the coil then moves on in order to set itself again in a plane at right angles to the lines of magnetic force, but now with its face reversed. In this way a continuous rotation is sustained in the coil, and work is done in driving the armature at the expense of the battery current, as will hereafter appear.

(To be continued.)

INCANDESCENT LAMP MANUFACTURE.—III.

BY J. SWINBURNE.

Amyloid Carbon.

Most makers of lamps are now agreed that Swan was right when he insisted that lamp carbons should be homogeneous and structureless. The most important homogeneous carbon by far is prepared from amyloid. Lane-Fox was the first to patent carbon made by carbonising parchmentised cellulose. He used vulcanised fibre, which is cellulose more or less parchmentised by chloride of zinc.

Swan, quite independently of Lane-Fox, worked out a carbon made from parchment paper or cotton.

The chemistry of the processes now to be described is somewhat obscure. Cellulose is nearly the sole constituent of such things as paper, cotton, linen, &c., and the object aimed at is to make a compound having the same chemical composition as cellulose, but very different physical characteristics. The process best known is acting by sulphuric acid. What is known as parchment paper, or vegetable parchment, is made by dipping blotting paper, or some loose-textured, unsized paper, in fairly strong acid. The acid seems to convert it into a soluble body, and partly to dissolve it, thus destroying the fibre. At this stage the action is stopped, and a tough, homogeneous, horny, semi-transparent substance is obtained. This can be made by a number of methods, and the substance seems to be the same though made by very different processes. The writer has called this substance amyloid, but he cannot now remember where he got the name from, or whether it is really a correct term. He thinks, however, it was given by Hofmann, and it may serve as a generic name for amorphous cellulose, however prepared.

The methods of making amyloid may be roughly divided into four classes. Cellulose may be treated with agents with a very strong affinity for water, such as sulphuric acid, zinc chloride, &c. It may be converted into a substitution product, as by the action of nitro-sulphuric acid, and the substitution product may be dissolved, and then precipitated in a non-fibrous form, and reconverted to its original chemical composition. Thirdly, cellulose may be acted on directly by a solvent, such as Schweitzer's magnet, and precipitated. Lastly, amyloid may be prepared by roundabout processes from such bodies as starch, seaweed, &c. This last is somewhat doubtful.

Cellulose has the composition $C_6H_{10}O_5$, or some multiple of it. It therefore consists of the elements of water combined with carbon. Of course it does not follow that the hydrogen and oxygen are combined in any way as water; but from the action of dehydrating agents it may be asssumed that that is to some extent the case. If cotton wool is put in sulphuric acid of the right strength, the acid seems to abstract water and form a compound which is partly soluble in sulphuric acid of that strength. If the action of the acid is then checked by immer-

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sion in water, the compound seems to take up water again, and also to be precipitated. What the composition of the body is while partially dissolved in the acid cannot be known; but it is hardly likely that it remains $C_6 H_{10} O_5$ right through, and it is more likely that water is abstracted by the acid, and is replaced again on dilution. This is the more probable, as various bodies act similarly on cellulose which have no points of similarity among themselves except their strong affinity for water.

If the cotton wool were left longer in the acid, it would, on the addition of water, give dextrin, another substance with the same percentage composition as the original cellulose. The dextrin so formed is not quite the same as dextrin made from starch in the usual way, as it rotates the plane of polarised light to the left instead of to the right.

The sulphuric acid process may be described first, as it is by far the most important.

To make thread carbons, sulphuric acid is diluted to 1·64 s.g. Swan, in his specification 4,933, 1880, gives the best strength as 2 of oil of vitriol to 1 of water. This is somewhat weaker than 1·64, but the writer finds 1·64 best. The thread used should be of very loose texture, and still as even as possible. For carbons for ordinary 50 volt lamps knitting cotton is the best available material. No. 8 is a good size. For finer carbons embroidery cotton is better, as it is more even in texture. Swan mentions crotchet cotton as the best, but crotchet cotton is far too close in texture for use. No doubt the best material for 50 volt lamps would be embroidery cotton also, but unfortunately it is not made thick enough.

Some practice is necessary to enable any one to make carbons successfully by the sulphuric acid process. In fact, all the amyloid processes are very troublesome. In order to get an idea of the process, a short piece of knitting cotton may be dipped in the acid, and held up and watched. It will almost immediately begin to get transparent, and the little strands on the far side will become visible, making the thread look as if it were plaited. Any little lumps or irregularities on the outside will sink in, and the material will gradually become like an even string of raw white of egg. It will soon break by its own weight, and if then laid on a piece of glass it will gradually become liquid, the cellulose being converted into dextrin. If, at the moment the cotton appears thoroughly gelatinised, and before it is soft enough to break, it is dipped in water and washed, the action is checked, and the amyloid thread is produced. On immersion in water the outside of the thread turns white, just as white of egg does in hot water. The thread gradually becomes white and opaque right through. If it is now thoroughly washed in water, and then hung up to dry, with a small weight to keep it taut, it will shrink a great deal, and dry into a horny thread. If the thread is cut, or if the rough surface is polished, it will be found to be colourless and nearly transparent, looking like catgut. No sign of the original twist of the cotton should be visible.

The great difficulty is to immerse the thread in water exactly at the right moment. If it is immersed too soon the organic structure of the cotton is not completely destroyed, and if it is not immersed soon enough it falls to pieces, and is weak. If the acid is used weaker the thread is not so thoroughly acted upon.

In the laboratory the cotton thread may be wound on glass rods, or on frames, and dipped into the acid. In manufacture this does not give uniform results. The cotton thread is therefore passed continuously through an acid bath into water. Large drums of copper gauze are slowly turned in tanks of water. These are driven from the engine, so as to get even motion. A drum of knitting cotton is mounted so that it can unwind easily. The thread unwound from it goes under the surface of the acid, being made to pass under a sort of glass bridge. On emerging it rises over a very loose-running porcelain pulley, and then goes down into the washing tank, where it it is wound on the copper drum. The drum has a screw traverse motion, so that the material is wound on one layer deep. There must be very little friction in the system, otherwise the thread will break just before it gets to the water. The time of immersion of the thread is regulated by the length of the acid bath, the speed of the drum, and the distance between the acid bath and the washing tank. The writer prefers to put a glass T piece above the surface of the water. It is held in such a position that the thread passes through the cross-piece freely, and the shank is connected by a rubber tube to the water supply. The ends of the T are slightly contracted, so that the water squirts gently past the thread. By this means the action of the acid is suddenly and thoroughly arrested at a definite point. Sulphuric acid of this strength rapidly absorbs water from the air, so the bath must be covered over as well as possible, or else so little acid must be used that the bath has to be very frequently filled up with fresh acid.

The great difficulty is in always getting the same amyloid with certainty in manufacture. Probably it always contains a little unaltered cotton, some dextrin, and perhaps a little glucose. Slight differences of time of immersion, of strength of acid, or of temperature, will make very great differences in the carbons made by Swan's process. The writer finds the addition of metaphosphoric acid to the sulphuric acid beneficial. It seems to check the second action, or the formation of dextrin, so that strong acid may be used so as to convert the cotton thoroughly with less danger of the thread breaking just before immersion in the water.

Water is kept running through the tank with the copper drum, and when the drum is full it is put in another tank and left so that the thread may be very thoroughly washed. The least trace of acid left in the prepared thread is fatal, as it will act on it as the thread is dried.

To dry the prepared thread it is hung vertically or horizontally in such a way that it is always kept taut by little weights. It may easily be arranged zig-zag down the side of a room, passing over little loose wooden pulleys. One end is then fixed, and a weight is hung on the other. When quite dry and horny the prepared thread is taken down to undergo the next process, which is cutting down to gauge. This amyloid is exceedingly difficult to cut satisfactorily, as it takes the edge off such a thing as hard steel. It was only after great patience and many experiments that Messrs. J. W. Swan and Alfred Swan succeeded in cutting the material properly. A series of jewels like wire-drawing jewels are used; but the holes are cut differently. The holes are tapered one way only, so as to leave a sharp edge on one side, and the thread is drawn through, entering at the small end of the tapered hole. To give ease in starting, the dies are made to open, and when the thread is placed in them they are held shut by springs or are clamped. There is some trouble in getting such apparatus made well, and it is very much better to use dies that are not split. If the holes of the series decrease very little at a time, there is little chance of breakage of the thread if care is used. Of course the thread must be pulled through only one die at a time, not through five or six. Guides should be arranged so that the thread does not "chatter," else it may be cut all over little waves. For experimental work a die may be made by drawing out a piece of glass quill in the blow pipe flame, and breaking it at the narrowest part.

For flat thread carbons a loose texture braid is used instead of knitting or embroidery cotton. This flat braid is not generally to be got very fine; so that such carbons can only be used for 40 or 50 candle-power lamps.

The writer has had some beautiful fine flat braids made for him by silk spinners. Some of these were fine enough to be used for 10-candle 80-volt lamps.

After being cut down to the right size, the thread is ready for carbonisation.

It should at this stage be nearly transparent, like catgut, and there should be no traces of white fibres or of the original twist of the cotton visible in the centre.

This material is very hygroscopic, and swelling and contracting is the cause of some error in the surface of the carbon. If the material is damp when cut down it will make a thinner carbon than intended.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 10th inst. amounted to £4,440.

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THE MAGNETIC CIRCUIT.

The following are the lemmas employed by Prof. Forbes* for obtaining the magnetic conductivity of different portions of the air circuit of a magnet, in order to calculate the total leakage:—

Lemma 1.—Between two opposed surfaces (Fig. 1) the conductivity may be measured by half the sum of the surfaces divided by the distance between them.

$$\kappa = \frac{\frac{1}{2}\,A\,B + C\,D}{E\,F} \times a$$

where a is the width perpendicular to the plane of the paper.

Lemma 2.—If the two surfaces are in the same plane (Fig. 2), and the air space does not exceed a certain distance, κ may be taken as

$$\kappa = \frac{1}{\pi} \log_e \frac{O\,B}{O\,A} \times a,$$

where O is centre line of the air space.

Whether this form or the next should be employed is a matter which must be left to the judgment of the investigator.

Lemma 3 relates to the same condition as the preceding, except that the air space is greater (Fig. 3).

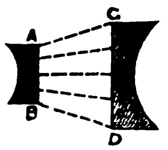


Fig. 1.

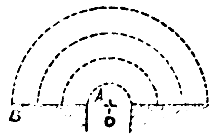


Fig. 2.

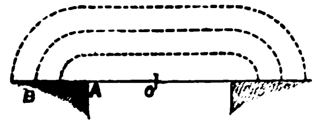


Fig. 3.

The formula in this case becomes

$$\kappa = \frac{1}{\pi} \log_e \frac{\pi\,.\,A\,B + 2\,O\,A}{2\,O\,A} \times a.$$

The difference between the values obtained by the two latter formulæ will be found, for medium distances, to be very small.

At a recent meeting of the Academie des Sciénces M. Leduc presented the following table, showing the induction which he had found to exist in the median plane between the poles of a certain magnet for different degress of exciting power and different distances between the pole-pieces:—

D centimetres.	Strength of field in C.-G.-S. units. 2 amp.	4 amp.	8 amp.	16 amp.	32 amp.
0·25	9060	13400	16930	19400	21100
0·50	5400	9200	12960	16130	18800
1·0	2780	5460	8440	12200	15830
2·0	1430	2820	4800	7320	10930
4·0	750	1500	2750	4200	6500
8·0	369	720	1370	2140	3400

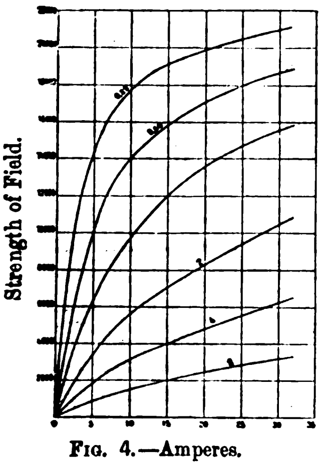


Fig. 4.—Amperes.

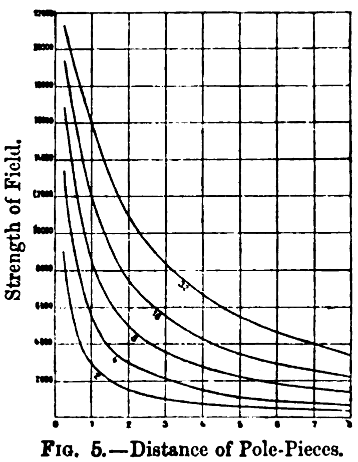


Fig. 5.—Distance of Pole-Pieces.

* See *Electrician*, Nov. 26, p. 63, Prof. Forbes's speech at the Society of Telegraph-Engineers.

Figs. 4 and 5 exhibit the results in graphic form. It would be interesting to see whether the recent investigations of Mr. Kapp, the Drs. Hopkinson, Prof. Forbes, and others had afforded the means for obtaining by calculation the remaining curves for varying distances of pole-pieces when one such curve is given.

At our request M. Leduc has courteously forwarded us a sketch (Fig. 6) (drawn to scale) of the magnet with which the observations were made, so that if any of our readers care to attack the problem the data are before them. We fear, however, that the task would be one of great difficulty, owing to the somewhat complex form of the magnet and the varying section of the iron. The magnet is provided with a cylindrical hole in the pole-pieces for the purpose of experiments on the rotation of the plane of polarisation. M. Leduc observed that his results were unaffected by the presence of iron in this space, a result which might be anticipated from the much greater total section of this part of the internal circuit. The

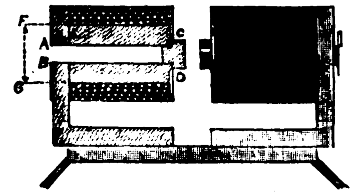
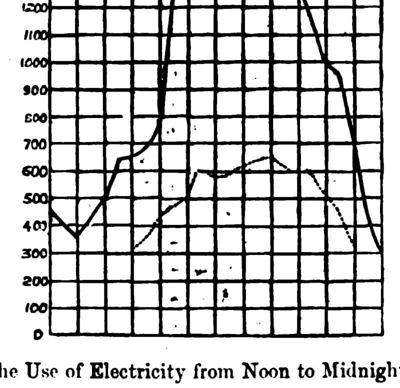


Fig. 6.

number of turns in each coil is 756. The dimensions are—E C, 28cm.; F G, 16cm.; C D, 7cm.; A B, 3·8cm. The width of the supporting frame may be taken at 14cm.

THE HOURLY VARIATIONS IN THE CURRENT FROM CENTRAL STATIONS.

The annexed diagram shows the hourly variation in the supply of current from a central lighting station at Boston.



The Use of Electricity from Noon to Midnight.

The installation consists of under 10,000 lamps, and the district chiefly consists of business premises, with a few private residences. The current in the daytime is chiefly required for running motors, the use of which is rapidly increasing. The full line shows the hourly consumption during an average weekday at this period of the year. The dotted line refers to a recent Sunday. It will be noted that during the whole period of supply the rate of change is remarkably rapid.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

NOTICE.

"THE ELECTRICIAN" will next week be published on THURSDAY instead of on Friday, and all Contributions and Advertisements must reach the office not later than first post on WEDNESDAY.

CONTENTS.

Notes ... 115
Elementary Electricity and Magnetism—II. (Continued.) Illustrated ... 120
Incandescent Lamp Manufacture.—III. By J. Swinburne 121
The Magnetic Circuit. Illus... 123
The Hourly Variations in the Current from Central Stations. Illustrated ... 123
SENSE AND SCIENCE ... 124
AFTER THE ELECTION ... 125
Correspondence ... 125 and 126
The Lighting of Taunton. Illustrated ... 126
A Relation between Magnetising Force and Core of Magnet. By E. L. French, B.S. (Illus.) 127
Society of Telegraph-Engineers 129
Motors for Electric Lighting ... 130
Glow Lamps, their Use and Manufacture. By Major-Gen. C. E. Webber, R.E., C.B. (Continued.) Illustrated ... 130
Physical Society ... 132
Legal Intelligence ... 132
Companies' Meetings— River Plate Telephone and Electric Light Company ... 136
Companies' Share List ... 136

SENSE AND SCIENCE.

The saying that an ounce of common sense is worth a ton of learning, although a rash and unscientific generalisation, is one that finds acceptance not exclusively among the unlearned, whom it flatters. If we substitute insight for common sense, and add the qualifying observation that there is no necessary antagonism between natural gifts and acquired talents, the aphorism would pass muster unchallenged even in learned communities, whom it seems to disparage. As a proof of this, we need only cite the respectful but languid attention manifested by a scientific audience when listening to a merely learned discourse, and compare it with the lively interest awakened in them by a man of true insight, and, as the vulgar call it, common sense. We shall not be suspected in this journal of underrating knowledge, or of rating too highly the *un*common sense which is meant when we talk of common sense, and which is in reality Wisdom. But we confess to a share of the weakness of ordinary mortals, and are not ashamed to own that we prefer a sensible thing without learning to a learned thing without sense. Whether an ounce of common sense without any learning is worth a ton of learning without any common sense is a question, perhaps, hardly worth discussing; only one thing, indeed, can be affirmed of it with certainty, namely, that their respective owners will never exchange possessions—the one because he is too sensible to part with what he prizes most; the other because he is too foolish to desire what he needs most.

Some such reflections as these were irresistibly presented to our mind during the progress of the discussion of Prof. FORBES' notes on some magnetic phenomena at the Society of Telegraph-Engineers and Electricians last week. The notes were of a speculative kind, and having been the subject of thought rather than of experiment, were eminently calculated to fill up a gap by inviting the unpremeditated commentary of persons who had given any thought in the same direction. The circumstances of the evening, as explained in our last week's issue, being favourable to desultory talk, there was a good deal of it, and it took a form that manifestly was exceptionally interesting to the audience. The learned members, so to speak, dropped their mantles and talked like ordinary human beings, bringing their insight, or common sense, to bear upon problems which at other times they are accustomed to treat in a highly scholastic fashion. We give elsewhere a report of Prof. FORBES' notes, but for the present we desire only to remark on the suggestions they gave rise to. Clearly the train of thought which had carried him so far would have taken him a good deal farther. One speaker said as much, and asked the question, why not treat the two things—current lines of force and magnetic lines of force, current pressure and magnetic pressure—with which Mr. FORBES was dealing as fundamentally identical, when all the phenomena relating to them seemed so plainly indicated to be the same, only under different names? We did not understand this to imply any disrespect to Prof. FORBES' method, but rather as expressing the speaker's satisfaction that the tendency of thought, as betrayed in the professor's discourse, was taking the direction his critic desired.

The general drift of the discussion did, in fact, point to that conclusion. We do not say it is the right one; all we wish to point out is that it is the conclusion which insight and common sense have arrived at long ago, but which learning has not yet condescended to seriously or carefully examine. Common sense may be wrong in this particular, but it cannot be so wrong as some of the scientific dicta of the received text-books, some of which are redeemed from absurdity only by the transparent sincerity of their compilers. They have become saturated with the formulæ handed down to them, and for every fresh discovery or difficulty they invent fresh explanations on precisely the same lines. It is here where a grain of homely sense and a little exercise of the imagination would prove invaluable. But these qualities the average student has been taught to neglect, or at all events to exercise with misgivings. He finds it safer, consequently, to follow on the approved track, and it is certainly easier. Only the free lances of science venture on independent courses of their own, and are invariably treated as ignorant heretics for their pains.

This is a fate they deserve when they treat learning as of no account; but a similar and not less severe judgment should be passed on the man of learning who treats common sense as of no account either. We once surprised a young student trying to induce a suspended glass needle to point north and south by rubbing it on his coat sleeve, and we at once understood his stolid refusal to follow the text-book explanation of the action of a galvanic cell. His imagination had dissolved some of our theoretical fictions into practical impossibilities, and he was essaying a reconstruction on the basis of his own intuition. We do not know what came of his bit of

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excited glass, which by some process of mental vision he had identified with the magnet; but we entertain the opinion that a man of that character is more nearly related to the Newtons and Faradays of the past than is the modern scientist who lets his imaginations rest in perpetual fallow.

We are not to be understood as reflecting on anything that transpired at the meeting to which reference has been made. Quite the contrary; the discourse and the discussion following it were most suggestive, and entirely of a kind we should like to more often listen to—although we confess to not understanding how Prof. FORBES is to obtain a field of force in the interior of his iron cylinder if wound like a Gramme ring, but with only one coil. Neither are we unmindful of the practical and, perhaps, necessary difference which will always exist between the analytical and the constructive intellect in man. Both have their special but distinct fields of operations. But they must not be confused the one with the other, much less the one for the other. It is possible to look so closely into a thing that you cannot see it—that is to say, cannot see the thing itself, but only its constituent parts. The man who can step back and look at it as a whole, if he has any real insight, will assuredly form a truer conception of it than will the mere analyst. It is given but to few men to be endowed with both these faculties in their highest development; but all men can try both methods, and our advice is, do not be too closely wedded to one method only. To tie yourself down to what you can tangibly handle, test, measure, and weigh, is, perhaps, the worst of all methods, resulting only in a barren array of figures, while somebody else, with keener perceptions and a wider range of vision, has already reaped the harvest.

AFTER THE ELECTION.

We have but a very few words to add to the remarks which were penned just before going to press, and immediately after the election proceedings at the Society of Telegraph-Engineers, last week. The delay which occurred in announcing the result showed that there must have been a good deal of what is called "cross voting," and that nothing in the nature of an organised effort to promote any particular "ticket" had been attempted. The patience with which the members waited for the result showed, on the other hand, that individually each and all of them were interested to learn it. We congratulate the members on this healthy sign of vitality, which, to our thinking, will tend to do the Society far more good than the rejection of a few deserving candidates can possibly do harm. The labours of the scrutineers may be expedited by adding still further to their numbers, and by preparing a methodical scheme of counting beforehand. We are quite aware of the objections and difficulties arising from submitting a larger number of names to be voted upon than there are men to be elected; but nothing can be so objectionable as the opposite course, and we trust that the one adopted last year and this will be steadily persevered in. As to the persons elected, we could have wished that the choice in some instances had been different; but the members, as a body, having expressed their wishes, we cheerfully accept the situation, and recommend all our friends to do the same. While it was our plain duty to give expression to the opinions of an influential section of the Society whose aims we cordially approved, it is equally plain that what we have to do now is to support its duly-elected officers in a loyal and generous spirit. The coming year may be an eventful one for the Society; and, under existing circumstances, it behoves us to spare no pains to bring it through the ordeal with dignity and credit.

CORRESPONDENCE.

COILS, UNITS, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think the interest of this matter justifies a few more words on my part, which I hope may be the last.

The arrangement of wires which I assumed agrees with that mentioned by Mr. Kapp in the first lines of his last letter. It does not seem to me that any approach to an accurate geometrical arrangement could be secured in any other way. With the wire wound as Mr. Kapp describes afterwards, it is clear that, if his rule is to be correct, each coil must touch the one below it only at the point where they cross, and must rest suspended in air throughout the rest of the turn. This cannot be. It will descend gradually into the groove, and after the half turn reascend on the other side. It would require a minute investigation to find out how it all really happens, and I think my remark as to the impossibility of securing an accurate geometrical arrangement is amply justified.

As to the change of figure of the section of the wire. Suppose you put a bit of soft wire in a vice and pinch it, you flatten it at the points of contact, and bulge it in the other directions. Here you have wire lying in a sort of long narrow vice, which compresses it (generally) at four points all along. Suppose that these yield in the least, the free parts of the wire will bulge, and the spaces will be more filled than if the figure were true. With very small wire a thousandth of an inch of such yielding would produce a considerable effect. It seems to me that such a pinch would be particularly liable to happen where two coils cross. In all this I only wish to illustrate my general opinion that the use of a mass of wire is not suitable for determining a cross-section accurately.

With respect to the units. Your correspondents all seem to think that Mr. Kapp's method is to enable them to get rid of C.-G.-S. But that is not so, at least according to your report. When your unit is 6,000 C.-G.-S. magnetic induction, all measures of magnetic induction must be made in C.-G.-S. as before, and then changed into the new unit. The only way of getting rid of C.-G.-S. is to adopt a similar system founded on other units, such as the foot-grain-second system which I mentioned before. I think we do better with C.-G.-S. as it is.—Yours, &c., R. H. M. BOSANQUET.

Dec. 12, 1886.

TESTING DYNAMO MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to Dr. Hopkinson's letter on dynamo testing, I may say that my article was in type before the Royal Society paper was published, and I would venture to suggest that much valuable technical information is lost when presented to the Royal Society. The paper of Drs. J. and E. Hopkinson hardly appeals to the students of pure science as much as it does to makers of dynamos. They very kindly sent me a copy of their paper when it was printed, but that was after my article was in type. This paper gives the data which I particularly desired. It seems from these very carefully made tests, that the very simple method described last in my article will be found quite accurate. The simplest case is that of a compound dynamo. To test such a machine, the normal electromotive force is put on the brush leads. The machine then runs at normal speed with a small current through the armature. The product of the back electromotive force and current then give the stray power, and this added to the shunt, main, and armature losses at any given load give the total loss in the machine. To be quite accurate the field should be a little more strongly excited, so as to get the full load electromotive force in the armature.—Yours, &c.,

JAS. SWINBURNE.

ELEMENTARY ELECTRICITY AND MAGNETISM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 10th inst., under the above heading, a paragraph on page 97 is devoted to the method of using

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a sine galvanometer. The author seems to consider a sine galvanometer as an instrument of definite form, the coil of which is capable of turning about a vertical axis. Also he seems to think it essential that the coil should be placed in the same plane as the magnetic axis of the needle. Such limitations are quite unnecessary, for *any galvanometer* capable of being turned round the axis about which the needle turns can be used as a sine galvanometer, and the law is true whatever be the angle between the needle and coil provided this angle be constant during one set of experiments. The necessary and sufficient conditions are:—1st. The controlling field must be uniform. 2nd. The relative positions of the needle and coils must be the same in one set of experiments. The same restrictions as described by the author of the article are to be found in nearly all elementary text books which describe the sine galvanometer, hence students obtain wrong impressions therefrom.

An endeavour to correct these common ideas must be my excuse for troubling you with this note.—Yours, &c.,

T. MATHER.

A LITTLE PUZZLE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly give me a little advice under the following difficulties through the correspondence columns of your valuable paper?

I have been trying to fit up an electric communication between my house and workshop, which are separated by a distance of fifty yards. I have erected a line wire of copper on insulators, and have placed bells and batteries at each end, with earth-plates consisting of galvanised corrugated iron, 24in. by 18in., buried in the earth 6ft. deep, with galvanised wire connections soldered to plates. Upon trying the current with Leclanché No. 2 cell, I was surprised to find neither bell would ring, so I put galvanometer in circuit, which gave a slight deflection, not nearly sufficient to ring a bell. By way of experiment I put two more cells in circuit, arranged first in series, then all in parallel, and to my surprise, the galvanometer showed exactly the same deflection as it did with the single cell. To prove where the fault lay, I attached an old rusty iron wire from the wires of each earth-plate, and each bell rang beautifully, which proved the fault to be in the plates. Now, what I should like to know is why are the plates at fault, especially when the earth is saturated with wet, as it is at this time of the year? All other telegraphic lines work with earth plates, and why will they not answer in my instance? Of course I could put an extra wire on, and it would work all right, but that would not be throwing any light on the difficulty, and I should still remain

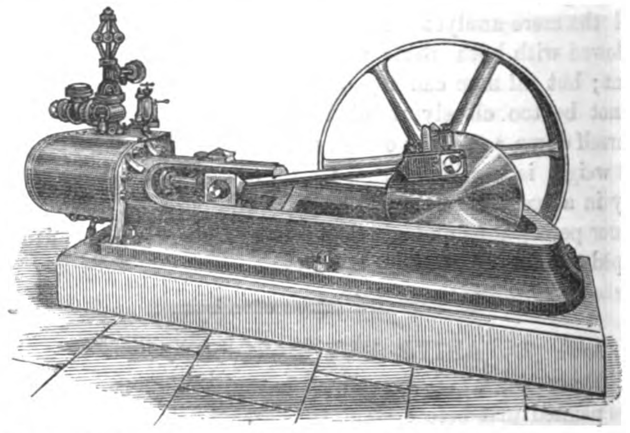
CONQUERED.

THE LIGHTING OF TAUNTON.

We have much pleasure in announcing that the Corporation of the Borough of Taunton has entered into a contract with Mr. Massingham, of Bath, to light the streets of the town by means of the Thomson-Houston arc light. The contract is signed for a period of seven years, but is terminable at the end of certain periods after three months' notice on either side. One of our representatives has recently visited Taunton, and inspected the progress of the work; Mr. Massingham at the same time courteously placed at his disposal a mass of information as to the financial aspect of the undertaking, the chief points of which will, at the present stage of public electric lighting in this country, prove interesting to a large number of our readers.

But before proceeding to these details it will be as well to give some description of the installation itself. The town of Taunton may be roughly described as consisting of three main streets, which meet in the centre at nearly equal angles; two of these are each about one mile long, while the third is much shorter. It is at, or quite close to, the point of intersection that the machines have been established. With a laudable desire to interest the local firms in his undertaking Mr. Massingham determined to place the order for both engines and boilers in the hands of Messrs. Easton and Waldegrave, of the Whitehall Ironworks, Taunton. The result has fully justified his selection. The engine is of the simple, non-condensing type, and works up to 40 indicated horse-power. It is of substantial design, and has a massive bed of the box girder type, with which the front cylinder cover and slide bars are in one casting, the latter being of bored pattern. The piston, slide rods, crank shaft, and all journals are of steel, the bearings being of phosphor bronze. All the moving parts are accurately balanced. A Pickering governor is fitted, and does its work thoroughly well, at a speed of 100 revolutions per minute. The power is taken from the fly-wheel, which has a diameter of 6ft. 2in., and drives on to a counter-shaft by means of a 12in. link leather belt.

The boiler, which is of the locomotive type, has an outside shell of steel; the firebox is of Lowmoor iron. The working pressure is 120lb. per square inch. Water is taken from the street mains into a large tank, and is thence supplied to the boilers by means of a feed pump. The boiler is in a separate room from that containing the engine and machines; but the length of the steam pipe does not exceed 8 or 10ft.



Non-Condensing Engine made by Messrs. Easton and Waldegrave, of Whitehall Ironworks, for the Taunton Installation.

There are at present in operation two 30-light Thomson-Houston dynamos, each giving a current of 6·8 amperes, and capable of working up to 1,500 volts. These machines are too well known to need further description here. Steps are now being taken to double the whole of this plant. Mr. Massingham is building a new boiler house and machine shed alongside of the present structure, but the whole of the additional arrangements will be carried out on the same general lines. In addition to the machines above mentioned there is an old-fashioned Edison dynamo with long magnets, giving 110 volts and about 50 amperes, for charging accumulators. These latter are used for lighting the Castle Hotel, which is close at hand, and is fitted throughout with 16 candle-power glow lamps. The distribution of light in the principal rooms of this hotel has been very skilfully carried out, and the whole installation is affording great satisfaction. When the extensions above referred to are completed, the incandescent plant will be increased to a capacity of about 150 sixteen candle-power lamps; but we shall not be surprised if at an early date Mr. Massingham finds it necessary to extend his operations considerably further in this direction. Something has been done in the way of running 16 candle-power lamps in multiple series upon the arc circuits, but the method has not been found altogether satisfactory up to the present time.

Coming now to the arc lighting as at present arranged, one of the 30-light machines is used for shop lighting and the other for street lamps. These machines have been running (under the present ownership) since May last, and under the superintendence of Mr. George Hooker, the electrician in charge, the work has been carried on entirely without hitch of any kind. It may be stated here that the town of Taunton is

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really indebted for the electric light in the first place to the enterprise of Messrs. Laing, Wharton and Down, the well-known representatives of the Thomson-Houston system in this country. Having, at the invitation of Mr. Massingham, broken ground in the locality, the firm ran the plant for some time with the intention of forming a local company to carry on the undertaking. But negotiations on this head having fallen through, Mr. Massingham came forward and, taking the entire responsibility on his own shoulders, he bought the plant and set to work to make the thing a success. There can be no doubt whatever that electric lighting would rapidly extend from one end of the country to the other, and would stand on a much sounder and more permanent financial basis if a larger number of individuals could be found, like Mr. Massingham, to embark their own capital, and give their own time and attention to its development in their own locality, instead of allowing what is now a purely industrial affair to be carried out (or otherwise) by the inevitable limited liability company. It is only the present lack of confidence among those on the look out for investments for their capital, and work for their hands and brain, that prevents such comparatively small industrial undertakings from springing up in every market town of the country. And, after all, the lighting of a few hundred lamps amounts to but a small undertaking from an industrial point of view.

Returning to more technical matters, the circuits are, at present, seven in number, and measure about two miles in extent. But so far only the central part of the town has been reached; when the contract for the street lighting is carried into effect, the circuits will be increased to 12 in number, and five or six miles of wire will be in use. The street lamp posts, which are of good height, are now being erected by and at the expense of the municipality. The wire employed corresponds to No. 8 B.W.G. It is of American manufacture, and is covered with asbestos braid. It is supported by Johnson and Phillips's fluid insulators—undoubtedly a wise precaution. For leading-in wires a stranded cable (7/18's) insulated with india rubber is employed. The resistance of the mains is about 1·28 ohm per 1,000 yards, which gives a loss of 8·7 volts corresponding to about 59 watts over that distance.

Turning now to the contract for lighting the town, the principal clauses are to the following effect:—The contractor provides everything essential for the installation and maintetenance of the lighting, with the single exception of the supports for the lamps and wires, which are provided by the Council. All the machinery is to be in duplicate, and arrangements are to be provided for immediate substitution in the event of a break down. On the occurrence of such a break down the Council to have the right, if they think fit, of terminating the contract at twenty-four hours' notice. Otherwise the contract is only to terminate at the end of the third or fifth year, upon three months' notice from either party. Thirty lamps, each of 1,200 candle-power, to be lit every night for an average period of eight hours, the Council to have the right either to extend the period to ten or to diminish it to six hours, with a proportionate variation in the rate. For the eight hours' (average) service the Council agree to pay the sum of £652. 10s. per annum. Another clause provides that every lamp shall be examined, the carbons trimmed, and the globes cleaned daily. The remainder of the town will be lit by oil, the Council dispensing altogether with the use of gas for street lighting. The report of the committee, who were appointed by the Council to investigate the matter, shows that the total annual cost of lighting the borough by gas for eight hours per night, based on the average of the last two years, amounts to £1,316 (gas costing 3s. per thousand), while the estimated cost of lighting by oil and electricity (including a sum for depreciation of the posts, which were to be supplied by the town) was only £1,329, showing a saving of £13 in favour of gas. For this trifling addition to their outlay they would get an incomparably better light in the centre of the town, and in the outskirts one quite as good in every respect as at present. Before arriving at this conclusion the committee made inquiries respecting the success and public estimation of oil lighting, from the town of Winchester, where it is exclusively adopted. The reply received proving of a thoroughly satisfactory character, the report of the committee was at once adopted.

The charges made to the shopkeepers for arc lights are as follows: For four days of the week from dusk till 8 p.m., Thursdays till 5 p.m., Saturdays till 10 p.m., £13. 10s. per annum. There is a scale of charges for longer hours, running up to a maximum of £18 for lighting from dust to 11 p.m. all the year round. This charge includes the supply of carbons, and trimming and cleaning the lamps. A charge of £1 is made towards the cost of fixing each arc lamp. If preferred, six incandescents are substituted for the arc lamp, and in that case 15s. is charged on each lamp fixed, and the fittings become the property of the customer.

It only remains to add the following remarkably encouraging figures:—On May 1st the total rentals of the installation amounted to £300 per annum, and the working expenses to £400. On January 1st, when the town contract comes into operation, the rentals will amount to £1,300, and the working expenses to £800, while there is every prospect of still further extensions in the early future. We offer Mr. Massingham our sincere congratulations on the services which he—a non technical man himself—has rendered to the progress of electric lighting in this country by means of a little enterprise, combined with sound business management and a judicious absence of parsimony in the original laying-out of his plans.

A RELATION BETWEEN MAGNETISING FORCE AND CORE OF MAGNET.*

BY E. L. FRENCH, B.S.

It has seemed to me that a formula which would enable a man to state the greatest number of ampere turns that could be used economically on a core of given size, might have some practical value. By "economical" use, I mean that the strength of the magnet increases rapidly per ampere, up to this number of turns, in comparison to what the increase is with a little greater number. It will be seen later that we cannot say exactly what this number is, since the bends in the saturation curves are not sharp ones.

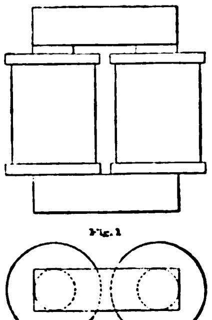

Fig. 1

The scheme of the experiment was as follows: To find the highest economical number of ampere turns for each of several electro-magnets, all of same type and material, and having cores whose diameters increase regularly by a small amount. To decide what was the highest economical current for each magnet (the turns being constant), by plotting a curve whose ordinates are proportional to strength of magnet, and abscissæ are proportional to amperes of current. Finally, to take these "highest economical currents" in amperes, and their corresponding diameter of cores in centimeters, and plot them for a final curve. The equation of this last curve will furnish a formula which gives us the diameter of core, when ampere turns are known, or gives the ampere turns when the diameter is known—provided the material and type is the same as in those magnets experimented upon. The type of magnets used is shown in Fig. 1, which gives plan and elevation. The cores are of circular cross section, and the armatures of square. Each edge of the cross section of armature equals the diameter of its corresponding core. Five such cores, with their arma-

* From the American *Electrician and Electrical Engineer* for December.

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tures, were made from patent cold rolled shafting, presented to the university by Jones and Laughlin, of Pittsburg, Pa., and used in a set of spools which would just admit of the largest core, as will be seen by the table of dimensions below :

Spools.

Internal diameter of tube.	Thickness of tube (brass).	Wire.	No. turns on each spool.
6·34 cm.	About 2 cm. ...	No. 10 copper wire, single wound, run ... through paraffin.	785

Cores. Diameter.		Length.	Armature. Section.		Length.
1·22 cm.	......	20·85 cm.	1·22 × 1·22 cm.	......	18·3 cm.
1·22	......	20 85	1·22 × 1·22	......	18·3
2·52	......	20·88	2·52 × 2·46	......	19·62
2 52	......	20·88	2·54 × 2·46	......	19·62
3·76	......	20·82	3·80 × 3·74	......	20·90
3·76	......	20·82	3·80 × 3·74	......	20·90
5·03	......	20·82	5·10 × 5·02	......	22·04
5·03	......	20·82	5·10 × 5·02	......	22·04
6·34	......	20·88	6·32 × 6·30	......	23·90
6·34	......	20·88	6·36 × 6·30	......	23·92

Armatures of section 2·52 × 2·46 and 2·54 × 2·46 were steel, Jones and Laughlin's not having the cold-rolled shafting on hand. The extreme length of the spools was about 1 cm. less than the length of cores, to admit placing a narrow coil of fine wire close around the pole above the spool. The surfaces of the armatures were planed smooth and the ends of cores squared off (in a lathe) at the Sibley College shops.

In all tests made by me, the magnets were set up as shown in Fig. 1. In making experiments on the magnets to determine the highest economical number of ampere turns, the connections were made as shown in Fig. 2. The current was

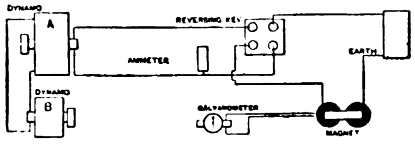

Fig. 2

furnished by a Gramme dynamo, A, which had its magnets magnetised by a small Weston, B. A Siemens and Halske electro-dynamometer was used to measure the larger currents, and a Thompson ammeter for the smaller ones. The galvanometer was a heavy astatic one. The ammeter was placed near the reversing key, and the galvanometer was on the farther side of the same room. The magnet was placed in a distant part of the laboratory, while the dynamos were still farther away. The narrow coil of fine wire placed close around the pole was in circuit with the galvanometer.

Now, a reversal of the magnet poles, by reversing the current through the magnet, causes a deflection of the galvanometer, since an induced current is generated in the narrow coil at the instant of reversing. The sine of the half angle of deflection is proportional to the strength of the magnet. In my experiments the angle was small, and I have used the double deflections—*i.e.*, the difference of the right and left deflections as read from scale.

The induced circuit was always broken, except at time of reversals, and till the galvanometer reading was taken. This prevented, to a great extent, any disturbance of the galvanometer by fluctuations of current from the dynamo. It was convenient to place the key for closing the induced circuit upon the table that supported the telescope and scale for reading the galvanometer ; hence a peculiar form of key was made that could be closed by pulling a cord, while standing at the other side of the room near the reversing key and ammeter.

Let us suppose the dynamos running, and the ammeter indicating a steady current ; also the galvanometer at rest. I stand by the reversing key, note the reading of the ammeter, close the induced circuit (by means of the cord), reverse the current, and step quickly across the room to read the first swing of the galvanometer.

Four such reversals were made with each current, and the mean of the two double deflections used. Thus we have strength of current, and a number proportional to strength of magnet. The saturation curves for the different magnets are shown in Fig. 5.

To determine what the highest economical current is for a magnet, I drew a line coinciding with the rapid rise of the saturation curve, and another with the nearly horizontal part of it, and produced them till they intersected, then bisected the angle thus formed. This bisecting line cuts the curve at a point midway between greatest economy and greatest waste of current. This method gives similar points in each curve. Ordinates of points thus determined are given below, opposite their corresponding dimeter of core.

Current.	Diameter core.
·35 am.	1·22 cm.
·55	2·52
·83	3·76
1·37	5·03
1·52	6·34

Plotting currents as abscissæ, and diameters as ordinates, we have the "final curve," also shown in Fig. 5. The equation

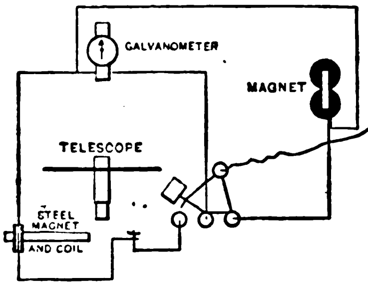

Fig. 3

of this curve is $y = 8{\cdot}8868\ x^4 - 25{\cdot}80116\ x^3 + 22{\cdot}07239\ x^2 - {\cdot}93553\ x - {\cdot}22125$; but the following simpler equation gives close results, when values of x from the above table are substituted :—$y = 9\ x^4 - 26\ x^3 + 22\ x^2 - {\cdot}7\ x - {\cdot}22$.

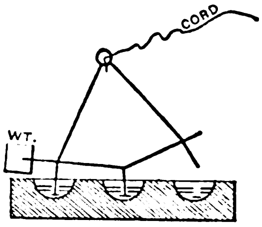

Fig. 4

If we substitute for x ·83 (see table) we have 3·76 cm. for the diameter of core which would be brought up to greatest economical strength by ·83 x 1570 ampere turns. Again, if we substitute a value for y and solve for x we must multiply the value of x by 1570 (the number of turns on spools) to get the ampere turns.

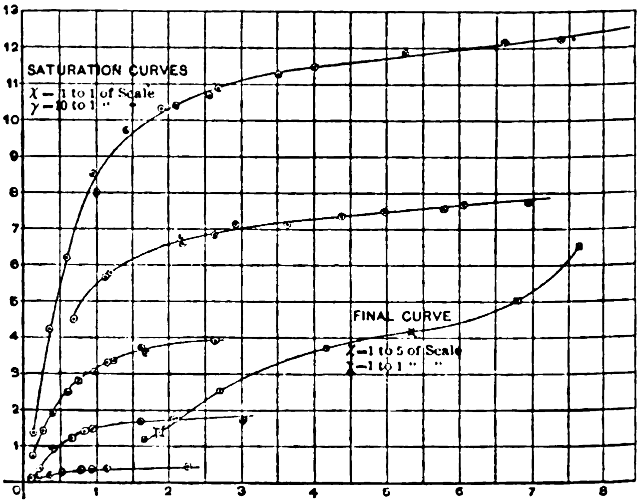

Fig. 5.

Fig. 3 shows more fully the connections with galvanometer at time of reversal. Fig. 4 is a larger view of key for closing induced circuit.

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When the experiment was begun, I intended also to use for the smallest two cores a set of smaller spools of No. 14 wire, with same number of turns as the larger, to see if a different "highest economical current" would be obtained. Also to make tests of magnets with one armature off, and also to test a magnet with differently prepared surfaces of contact between armature and core. These experiments were omitted for want of time. It will be seen that the method of reversals is that of Prof. Rowland.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The annual general meeting of this Society was held on Thursday, Dec. 2, at the Institute of Civil Engineers, Prof. Hughes, F.R.S. (President of the Society) in the chair. The Secretary having read the annual report, which showed that the Society was in a flourishing condition financially, and continued to increase in numbers and importance, votes of thanks were passed to the honorary officers of the Society both at home and abroad, to the Institute of Civil Engineers for their continued hospitality, to the donors of books for the library, and to others. The election of officers for the ensuing twelve months was then proceeded with, the results of which we were enabled to announce last week. During the scrutiny of the votes the discussion on Mr. Swinburne's paper took place, but as we are not able to complete this paper in the present issue we must reserve the remarks of the speakers.

The President then called upon Prof. Forbes, who had very kindly undertaken to fill up the remainder of the evening by speaking on "Some Magnetic Problems."

Prof. Forbes said that he had some hesitation in bringing these notes before the Society, because they mainly consisted of ideas suggested from theoretical considerations, and he had not as yet undertaken their experimental verification. He, however, had consented to occupy their attention that evening with this subject, in the hope that others who had more time or greater facilities than he himself possessed at the moment might be induced to put these ideas to the test. It has no doubt suggested itself to many people to inquire whether the labours of Œrsted, Faraday, Ampère, and Sturgeon have really extended over the whole field of electro-magnetic phenomena. Now, there is certainly one direction in which these phenomena have not been fully developed by experiment, and all the suggestions which he was about to make were founded upon this one idea—the idea of *a magnetic current.* If we have a long iron wire with a coil at the end, then when we pass a current through the coil the wire will be magnetised throughout its length. During the rearrangement of the molecules which ensues while the magnetisation is proceeding along the wire we have what may be called a magnetic current. The question then arises, what are the distinctive properties of this magnetic current? Some of these properties are already well known to many of those present. Suppose that we have an iron ring, wound with a coil of insulated wire continuously in the same direction. Then at the moment that an electric current either commences, is reversed, or ceases in the wire, we know that an E.M.F. is created along certain lines of induction, passing through the axis of the ring, and returning outside. If a conductor occupy any part of this space a current will be set up in it, but if there be no conductor present a strain is set up in the insulating medium. But if a charged body be present in a space where such a strain exists, then, if negatively charged, it will tend to move in the direction in which this strain is acting. Consequently a charged body placed at the centre of our ring should experience a force acting upon it at the moment of any change in the current through the coil. This is the first experiment which it is desirable to undertake. The effect would, however, be very small. He (Prof. Forbes) had calculated that in a particular wire, at a distance of two metres along an iron wire measured from the position of the inducing coil, the induction was only ·0001 of its value at the coil itself. Of course the conditions of the experiment which he had suggested were not exactly of the same character. He proposed the following method as likely to give measurable results:—Let a cylinder ring be wound all over with copper wire continuously in the same direction, like a Gramme ring, and placed with its axis horizontal. Within this cylinder the charged body would be suspended by a silk fibre, and would consist of a pair of concentric and separately insulated metallic segments, which could be charged like a Leyden jar, one pair being positive and the other negative. Then on magnetising or reversing the magnetisation of the ring by means of the current in the coil, a deflection should take place, and could be rendered visible by a light mirror in the usual way. Such an instrument would at once find an application in the measurement of the work done by an alternating current—a measurement which, as many of those present would know, involved difficulties of the most serious character. In fact, at the present time the employment of the calorimeter was really the only trustworthy method at their disposal. At the same time, the measurement of the work done by such currents was daily becoming more and more important, owing to the extended use of secondary generators. It is perfectly easy to measure separately the E.M.F. and the current, but what we want to know is the value of these two factors *at the same instant of time.* Our instruments tell us the mean alternating values, but the periods of maximum and minimum of the E.M.F. and current respectively do not correspond. Suppose, however, we had such an instrument as has been suggested, then we may send the alternating current through the coils of the Gramme ring, and at the same time we may connect the terminals of the circuit, where the work which we wish to measure is being done, to the segments which have to be charged; consequently, the segments will at every instant be electrified to the potential which we wish to measure, and the deflection of the discs will then be proportional to (or some function of) the product of this potential *and of the magnetisation of the ring by the current in the coils.* This arrangement does not, therefore (without some further modification), give us the quantity which we seek, but it gives the product of the potential into the differential of the current in respect to its period, because it is to this that the intensity of the *magnetic* current is proportional. Therefore, in order to adapt such an instrument to actual work it would be necessary to provide an additional pair of coils, wound upon one core, through one of which the primary current to be measured would be sent while the secondary induced current would then be passed through the coil of the instrument itself, and the phase of the magnetic current would thus be restored to synchronism with that of the first electrical current. This is only an introduction to the subject of magnetic currents, but he (Prof. Forbes) had no doubt that upon studying the matter for themselves they will discover an almost complete analogy between a magnetic current and a charged electrified body on the one hand, and an electric current and a magnetic pole on the other. Imagine, now, two parallel iron wires; let us inquire whether, when they are each traversed by magnetic currents, there would be any attraction or repulsion between them. It will be found that the analogy of electric currents holds good completely. If the currents are in the same direction we have attraction, if in opposite directions repulsion. Without going very fully into this, I think you will be able to see that this is right from the following illustration:—We have already seen that a charged body is attracted towards the axis of an iron ring through which a magnet current is passing. It therefore follows that the ring tends equally to move towards an electric field in its neighbourhood, parallel to the lines of E.M.F. Now, what does that lead us to? Suppose we have two rings placed one above the other. Each of these will, we know, create an E.M.F. in its neighbourhood when traversed by a magnetic current. Hence, if both are traversed by similar currents they tend to approach one another. And it is of course equally easy to show that if the current in one of them is reversed a repulsion is set up. If, now, we extend the size of the rings indefinitely, we can at once apply the same principles to the case of two parallel wires. Let us consider the question a little further. The attraction which exists between the two wires conveying similar magnetic currents must represent a certain amount of energy, and if work is done it must clearly be at the expense of the magnetic current itself; or, in other words, the approval of one magnetic current towards another induces a counter E.M.F. tending to diminish the strength of the magnetic currents. We may say, if you like, that a magneto-motive force is created which tends to set up a magnetic current in the opposite direction. This leads me to the fact that if I have a magnetic current travelling through one wire and approaching a second iron wire, it induces in that wire a magnetic current opposite in direction to the inducing current—one more analogy with the laws of electric currents. I need not go on and complete this by pointing out that a secession of one wire from the other will create a magnetic current in the same direction, or that the sudden making and breaking of the current in one wire without approach will suffice to create a current in the opposite direction in the second. Prof. Forbes concluded his remarks by again expressing a hope that the experimental study of the subject would be undertaken by some member of the Society.

Mr. Swinburne asked for some further explanation as to the action of Prof. Forbes' proposed instrument.

Mr. Biggs referred to the necessity for recognising electric and magnetic phenomena as having a common basis.

Mr. Preece agreed with Mr. Biggs' views as to the desirability of ceasing to draw a hard and fast line between electric and magnetic phenomena.

Mr. Snell described the use of Mr. Blakesley's method of determining the coefficient of self-induction.

Mr. Gisbert Kapp sketched on the blackboard an illustration of a simple hydraulic analogy.

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Prof. AYRTON mentioned a remarkable experiment which he had in progress, by which the absolute velocity of the earth in space might be determined.

We regret that the extreme pressure on our space still compels us to hold over Mr. Swinburne's paper on "Secondary Battery Experiments."

MOTORS FOR ELECTRIC LIGHTING.

By the courtesy of the Secretary of the Society of Arts we have been favoured with an advanced proof of the following:—

The Council of the Society of Arts are prepared to award TWO GOLD MEDALS and FOUR SILVER MEDALS for prime motors suitable for electric light installations.

The medals will be awarded on the results of practical tests, the conditions for which are as follows:—

1. The motors will be divided into two classes, A and B. One gold and two silver medals will be awarded in each class.

(A.) MOTORS IN WHICH THE WORKING AGENT IS ALSO PRODUCED.

Steam.—Ordinary portable or semi-portable non-condensing engines.
Ordinary portable or semi-portable condensing engines.

Gas.—Coal gas or water gas with producer.
Petroleum vapour.
Liquid petroleum.

(B.) MOTORS TO WHICH THE WORKING AGENT MUST BE SUPPLIED.

Steam.—Detached engines, non-condensing, without boilers.
Detached engines, condensing, without boilers.

Gas.—Engines worked by illuminating or other gas.
Engines worked by raw gas without producers.

Hydraulic.—Water motors.

2. Each class will be subdivided into two groups—those declared to develop not more than 10 horse-power, and those which will develop more than 10 horse-power and less than 20 horse-power.

[The horse-power herein mentioned is equivalent to 33,000lb. raised one foot high in one minute, as measured on the brake]

3. The entrance fee will be £2. 10s. per horse-power, to be paid on entry.

4. No competition will be held unless ten motors at least are entered.

5. In case of no competition being held, the entrance fee will be returned.

6. The Council reserve the right of refusing any entry.

7. All engines and boilers must be fitted up in accordance with the Regulations of the Royal Agricultural Society, viz.:—

a. All boilers must be fitted with a steam pressure gauge. Before any engine can be worked the pressure gauge must be verified by the judges.

b. There is no restriction as to the construction of steam engines or boilers, but the judges must be satisfied that the bursting strength of the engine or boiler is at least four times its working pressure, and that a hydraulic test of one-and-a-half times the working pressure has been satisfactorily applied.

c. Each exhibitor must declare the greatest pressure at which he proposes to work his boiler or engine.

d. No old boilers, that is boilers that have manifestly been at work for a considerable time, will be admitted without special thorough examination and a certificate of safety from the judges.

e. Each boiler, of whatever form or size, must be provided with the following mountings:—

Two Safety Valves, each of sufficient size, to let off all the steam the boiler can generate, without allowing the pressure to rise 10 per cent. above the pressure to which the valve is set.

Two Sets of Gauges for ascertaining the water level.

One Steam Pressure Gauge, which must be tested and verified by the judges before the boiler can be used.

A Half-inch Cock, terminating in a half-inch male gas thread, for the purpose of receiving a testing pump.

One Check Feed Valve, immediately attached to the boiler, in addition to the ordinary pump valves, whenever the feed is introduced below the lowest safe water-level, or where there is a length of feed pipe between the engine and boiler.

f. Exhibitors must be provided with all the appliances necessary for taking the working parts of the machinery to pieces, for examination, should the judges require it.

g. Shafting, belts, gearing, high speed machinery, and any other exhibits likely to prove dangerous, shall be securely fenced and protected to the satisfaction of the judges, but such approval shall not relieve the exhibitor from his own liability.

8. The points of merit considered of the greatest importance are—

a Regularity of speed as to revolutions per minute under varying loads.
b. Regularity of speed during the various parts of one revolution.
c. Power of automatically varying speed to suit arc lights.
d. Noiselessness.
e. First cost.
f. Cost of running.
g. Cost of maintenance.

9. The tests will be carried out under the direction of three judges appointed by the Council of the Society of Arts, who will report to the Council, and will confer with them on the awards.

10. The Council will publish the awards in the *Journal* of the Society of Arts. They reserve the right of publishing descriptions of any of the motors, and the competitors must afford every facility for this purpose.

11. The competitors must take upon themselves, in exoneration of the Society, all claims in respect of damage (if any) resulting from the testings, and must renounce all claims for compensation for any injuries, real or imaginary, that they may incur from alleged or actual imperfection in the testings, or from any statement in the report or description published.

12. The competition will take place in London about May or June next. Entries must be sent in by the 28th February, 1887.

13. All costs of fitting up and working the motors must be borne by the exhibitor. The Society will provide the brakes, indicators, and apparatus, electrical and other, necessary for making the tests.

14. The Council reserve the right of withholding any or all the medals.

GLOW LAMPS, THEIR USE AND MANUFACTURE.*

BY MAJOR-GENERAL C. E. WEBBER, R.E., C.B.

(Continued fom page 113.)

In a good glow lamp, inseparable from uniformity of resistance are uniformity of surface and incandesence. Uniformity of resistance when hot means that each lamp will (so to speak) consume the same amount of current, and this can only be secured by electrical measurement under the conditions of uniform electrical pressure. Uniformity of incandescence and surface means that lamps possessing these qualities give almost the same candle-power, and this can only be obtained in the manufacturing processes by visual measurement. To secure all three it is necessary to combine a means of visual and electrical measurement. The former is but approximate, the latter is as accurate as a Thompson's galvanometer can make it. In either case, however, when large numbers of filaments have to be standardised, neither measurement can be expected to produce greater accuracy than is essentially necessary for a good commercial lamp, and the fact is that while uniformity of E.M.F. is the condition which must not be departed from, no harm arises in practice if the current consumed and the candle-power are not absolutely uniform. Thus, the required resistance of each lamp is such a resistance as will, under the conditions of uniform E.M.F. or electrical pressure, give, with a small varying area of surface, such a candle-power as that to the eye all the lamps are alike when they are incandesced.

This required resistance is obtained in the following way by a process known in the electrical world as "flashing," a title which, I believe I am right in stating, owes its origin to Mr. Lane-Fox:—The baked filament is placed in these tongs and lowered into a glass chamber full of hydrocarbon gas. An electric current is passed through it, which raises it to a high temperature, and the carbon in the gas attaches itself to, or is deposited on, the heated surface. The use of this beautiful phenomenon is not essential, but is a very ready and simple means for rapidly increasing the size of the filament, and necessarily in consequence for reducing its electrical resistance. While this is being done the operator is being guided by the two means of measurement already mentioned, so as to know when he has reached the required standard, by reducing the resistance to that point, under a uniform electrical pressure (now generally expressed as "with a uniform voltage"), at which the state of incandescence is reached which yields light of the candle-power required in the lamps under manufacture. The process, as you see before you, is one which is most conveniently carried out intermittently and cautiously, as, inseparable from it, just as the thickness of the filament is increased, so the resistance diminishes, and more current is required to give the high temperature which attracts the carbon from the surrounding gas. The filaments having been thus standardised, they have to be mounted or attached to the metal conductors, which pass through the glass, and thus make their ends electrically in communication with the outer air.

An important condition of the result of any process of doing this must obviously be the obtaining of a good and perfect electrical contact or joint between the metal and the carbon. The absence of this would be fatal to the future of the lamp. Every inventor has laboured hard to secure this. The making of good joints between the ends of electric conductors has been, for the last thirty years, the subject of intense care to every engineer who deals with electricity. No wonder that its importance should be vital in the case of these two little connections, knowing that once sealed up in this bulb they cannot be got at again for repairs, and also knowing the intensity of the current to which they must be the path. In joining iron or copper wires to one another, telegraph engineers long ago knew the difference in the resistance of their lines due to the careful use of soldered joints, instead of leaving them what they call "dry." Various forms of joints have been devised so that the tensile connections between the wires and the surfaces in contact exposed to the deposition of solder should be sufficient to neutralise all resistance. The efficiency of such devices became more important when the joints for the purpose under consideration had to be designed, because of the necessity not only to neutralise resistance at these points in the circuit, but also to reduce it at this point in comparison to that of the carbon. Although this desideratum is ardently sought, in practice it is difficult to prevent heating at the joint when the current exceeds 1·4 of an ampere. Hence many very ingenious little contrivances, but all having the same object.

Next is the question of the solder to be used, and I believe that no one will dispute that Mr. Lane-Fox was the first to use the process of deposition of carbon by electrically heating the joint in a vessel containing an

* Paper read before the Society of Arts, Wednesday, December, 8, 1886.

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hydrocarbon surrounding, so as to solder the metal and carbon surfaces to one another. The way in which this is effected is pretty much the same in execution everywhere. The wire mount of platinum wire, or other suitable metallic conductor, is placed in contact with the carbon filament or bridge, so that they are kept together by any suitable contrivance of their ends, and the joint is then flashed. As any further deposition of carbon on the filament itself would alter the standard effected in the previous stage of the process of carbonisation, it will not answer to allow any current to pass through it. This is prevented by any simple means of short circuiting the current, so that it shall only pass through the joint. In the process carried out before you, this is done by this apparatus, which holds the filament in this vessel, which contains hydrocarbon in a liquid instead of in the gaseous form you saw used for carbonisation in the previous stage. Practically, the chemical phenomena are identical in each case, and the result in this one is a perfectly homogeneous electrical joint, larger in section than the other portions of the path of the current, and therefore of ample strength and conductivity to prevent risk of any future wear and tear through high temperature and rough usage.

There is not much to be said about the platinum mount. There are small details in its construction, and the manner of preventing its two sides coming into contact, which vary little in design, and all have the common object. You now see this done by the introduction of the little glass bridge piece. The platinum which should be used, its homogeneity and physical conditions, are all objects of experiment and great care, too minute with which to trouble this audience.

The Bulb.

Having completed this important factor in the construction of a glow lamp, let us turn to the envelope, or bulb, which is destined to be the home of the burner, under conditions for supporting combustion opposite to those under which any other means of illumination will act. In the latter the presence of oxygen in due proportion to the supply of hydrocarbon and other light-yielding gases is vital to its usefulness. In the former the presence of oxygen within the bulb and its contact with the carbon bridge is rapid death, instead of the slow decay, ending in extinction, which is the best that as yet can be expected from the glow lamp. Imperfect though it may be, it is, however, very good, and not likely to be superseded.

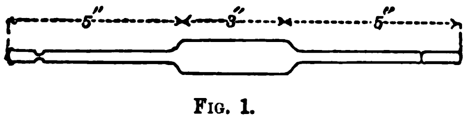

Fig. 1.

This little glass vessel has also its stages of manufacture, as you will see by the performance in your presence, the power of demonstrating which, together with the processes previously shown, I owe to the permission of the Board of the Anglo-American Brush Electric Light Corporation, whose factory and offices are situated on the Surrey side of the Thames, just over against Charing-cross. You see that a glass tube of about three-quarters of an inch interior diameter is the foundation. The first stage you see is to produce an object like this (Fig 1, previous col.), by drawing out the glass into a small tube of about five inches long, at each end of a section of the original tube about three inches long. Next the small tube is slightly contracted at (A), when the thick part is heated and blown to this shape :—

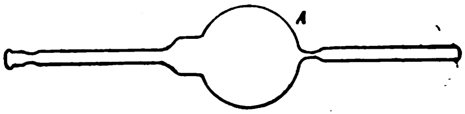

Fig. 2.

Under a second heating, with the object of completing the form of the bulb, it is brought to the following form (Fig. 3, below).

A Y is then cut off, and another tube of uniform section joined on in its place. This passage is afterwards used for exhausting. The bulb is now ready for the introduction of the filament, which has been prepared and mounted in the way you have seen. Z is warmed, the end taken off, and it is pressed into an elliptical shape. The filament is introduced, and under the influence of heat the glass is pressed around the platinum leads, and the little loops at their ends only are left projecting. The lamp is now ready for the last part of the manufacturing stage, in which a vacuum within the bulb is produced.

The last stage, namely, the exhaustion, is probably that upon which the life of the lamp most largely depends. This process, exemplified by the action of the mercury pump which you see here, is apparently a very simple one, and would be so were it not that there are several small impediments to success which, when one comes to demanding a vacuum of one millionth of an atmosphere, are very serious difficulties. In the first place, great attention must be paid to the construction of every part of the pump, for, with valves or taps of the ordinary kind, inevitable failure and waste of labour would ensue by leakage when the stage of high vacuum is being approached. I will avoid going into any description of the merits of the various forms of mercurial air pumps, because Prof.

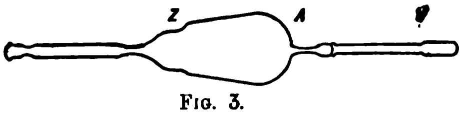

Fig. 3.

Silvanus Thompson will before long read a paper on that subject before this society, so I will pass on to some of the conditions of their use for exhausting glow lamps. It was found that the attempt to obtain such a vacuum as is required in the industry I have ventured to bring to your

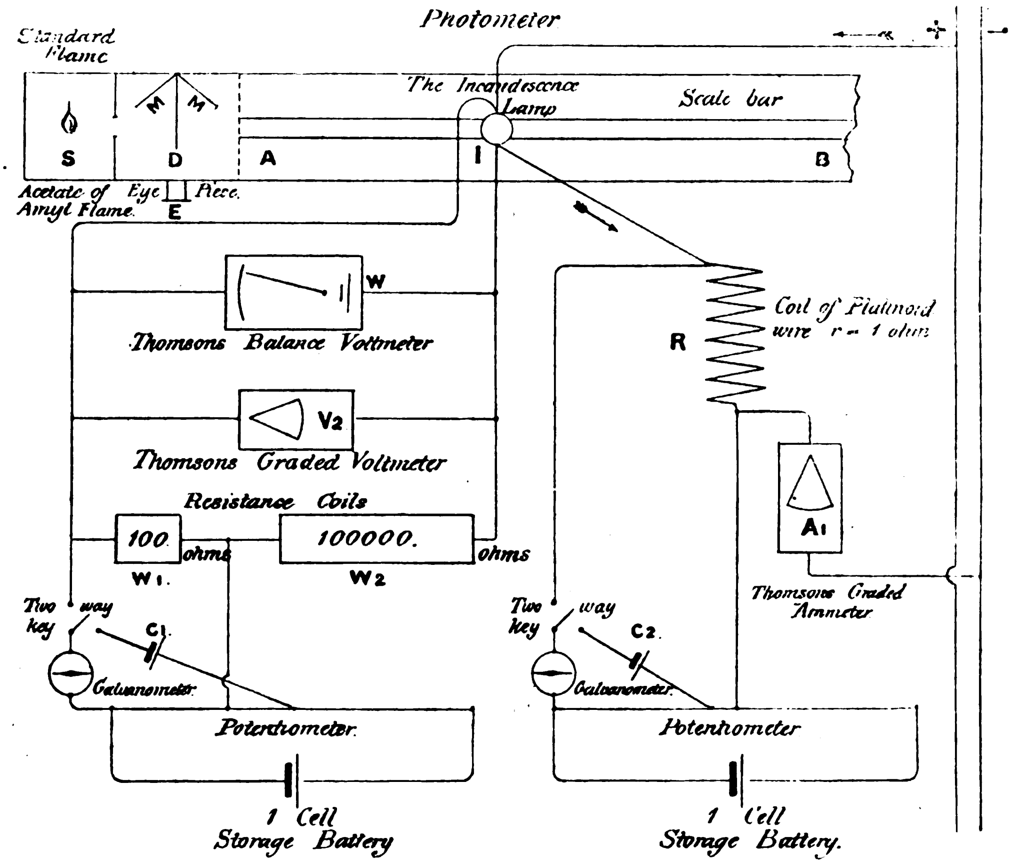

Fig. 4.

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notice to-night has to encounter the presence of moisture in the air, and the presence of air in the glass, in the platinum, and in the carbon. Besides, the process of exhaustion is the only vehicle for ridding the filament of what are called the occluded gases. A part of the moisture can be, and is, removed by absorbent substances placed inside the pumps, but alterations of temperature in the glass and in the filament, brought about by several means, which I cannot show here, are alone found to be really effective, and this application of heat to expel the moisture and air from the parts of the pump open to the lamp must be continued, with exhaustion, at certain stages of the operation, until by a suitable test it was found that the requisite degree of vacuum has been reached.

The best vacuum test is probably that which is made electrically. This is carried out with an induction coil of very high tension, and the test consists in observing when the sparks between two poles of platinum, placed in a part of the pump which shares the vacuum with the lamp under treatment, travels outside the glass instead of inside. The process of exhaustion in the early days of glow lamp making occupied three or four hours; now it has, by better appliances, been reduced in time to a little more than half-an-hour. The number of lamps turned out in a factory is determined by the number of lamps on each pump, generally three or four, and the number of pumps. Allowing ten removes a day, and twenty-five pumps, each having four lamps, a manufactory could turn out 1,000 lamps a day. The lamps are next tested and classified for candle-power and voltage, and marked accordingly; formerly 50 per cent. failed to give the standard of efficiency in those respects, now all are up to the mark within 10 per cent. The electrical efficiency of lamps is measured by the watts expended per candle-power. As is well known, economy in this direction effects a saving for a given amount of light required on an installation of electric lighting, in power converted into electricity, and in the size of the conductors which convey it to the lamps. Most makers' lamps vary between 3 and 5 watts per candle-power, when the lamps are new, under the conditions of voltage which gives the longest life. Those are alleged to be as follow:—Edison, 5 watts; Swan-Edison between 3·5 and 4 watts; Victoria, 3·5 watts; Woodhouse-Rawson, 3·0 watts.

The scientific man does not require to be told what are the tests to which he should subject glow lamps to prove their efficiency. At the Crystal Palace Exhibition, at Vienna, at the Health Exhibition, and at Philadelphia, very exhaustive tests were applied to the lamps of several well-known makers; but at the best all these have proved unsatisfactory, because the makers themselves were not likely to contribute their average lamp, and in some cases either declined to contribute at all or repudiated the results after they were published. The tests which require apparatus not usually outside a laboratory are those which observe the E.M.F., the current, the resistance, and the watts per candle-power. There are various arrangements for testing candle-power. I am indebted to Dr. Fleming for that which is shown on the diagram (Fig. 4, page 131).

The arrangement is a very special one for securing an accurate E.M.F. in the lamp in process of testing. The disc D of a photometer is fixed, instead of, as is usual, being left free to slide. The standard flame at S is a lamp of burning pear-oil, or acetate of amyl, with a flame of regulated height. The lamp I to be tested is placed on a carrier which slides along the scale bar A B. First, to test the current. The current which feeds the lamps passes along the mains plus and minus, *viâ* the minus through a Thompson's graded ammeter and a platinoid resistance, R, to one terminal of the lamp. The difference of potential between the termini of the coil is compared with the E.M.F. of a standard Clarke's cell, C_2, on a potentiometer. This latter is a perfect check on the accuracy of the ammeter. Second, to test the working E.M.F. at the termini of the lamp. Similarly this is made with a Thompson's balance voltmeter, W, as well as a Thompson's grade voltmeter, V_2, checked by measuring the difference of potential at the extremities of a 100 ohm coil W_1, in series with a 10,000 ohms coil W_2. The voltmeters themselves are placed between the terminals of the lamp, but by means of the resistances the potentiometer, with a Clarke's standard cell, is only compared with $\frac{1}{100}$ths C_1 of the E.M.F. of the lamp.

It will be understood that the standard cell in each is the ultimate check on the measuring instruments, provided the resistances are perfectly true, and if the latter do not agree with the former, they have to be re-calibrated. The need for standardising the measuring instuments used by electricians has been pressed home by Dr. Fleming to the conviction of every one concerned, but up till now little has been done beyond deliberation by a committee of the Society of Telegraph-Engineers and Electricians. At present we do not know that we all mean the same thing when we speak of some of these units of measurement.

(To be continued.)

PHYSICAL SOCIETY.—Dec. 11.

Prof. M'Leod, Vice-President, in the chair.

W. Natanson, Ed. Natanson, the Hon. R. Abercromby, Jul. Verteimer, and H. M. Elder were elected members of the society. The following papers were then read:—*On the Influence of Change of Condition from the Liquid to the Solid State on Vapour Pressure*, by Prof. W. Ramsay, Ph.D., and Sydney Young, D.Sc., read by Dr. Young. The authors refer to some experiments published in *Wiedemann's Annalen*, Vol. 28, p. 400, by W. Fischer, on the above subject, which show that the vapour pressure of ice and solid benzene are less than those of water and liquid benzene at the same temperatures. By using the formula $p=a+bt+ct^2$ to express the relation between the pressure and temperature of saturated vapours, Fischer arrives at the absurd result that the vapour pressure of liquid benzene is not identical with that of solid benzene at melting point. If the above formula be replaced by log $p=a+b\dot{}a^t$ it is shown that the anomaly disappears. The authors have measured the vapour pressures of solid and liquid benzene by the dynamical method, and obtain results agreeing closely with those of Fischer determined statically. They also calculate the vapour pressure of solid benzene from that of the liquid by using the formula

$$P_{t-1}=P_t-(P'_t-P'_{t-1})\left(\frac{V_{t-\frac{1}{2}}+F_{t-\frac{1}{2}}}{V_{t-\frac{1}{2}}}\right)$$

where P_t and P'_t are the vapour pressures of the solid and liquid at temperature t, $V_{t-\frac{1}{2}}$ = heat of vaporisation of liquid and $F_{t-\frac{1}{2}}$ = heat of fusion of solid at temperature $t-\frac{1}{2}$. The numbers so obtained are in accordance with those determined experimentally.

On the Nature of Liquids as Shown by the Thermal Properties of Stable and Dissociable Bodies, by the same authors, read by Prof. Ramsay. From experiments on the vapour density and heat of vaporisation of stable and dissociable bodies, the authors arrive at two important results. (1) That for stable bodies, such as alcohol and ether, the density of their saturated vapours increases with rise of temperature, whereas for bodies such as acetic acid and nitric peroxide the vapour density attains a minimum at certain temperatures, and increases with either rise or fall of temperature. (2) The heat of vaporisation of alcohol decreases with rise of temperature; but that of acetic acid attains a maximum at about 110deg. C., and decreases with rise or fall of temperature. From these results the authors seek to prove that the difference between stable liquids and their vapours consists in the relative proximity of the molecules, this proximity being greater in liquids than gases, and that the molecules of stable liquids are not more complex than those of their gases.—Prof. Pickering dissented from this view, and thought that the molecules of liquids are aggregations or compounds of those of the gases.—In answer to inquiries by the authors, Mr. Lewis Wright said bodies which rotate the plane of polarisation of light when in the liquid state also rotate it in a proportionate degree when gaseous, and Captain Abney remarked that stable liquids and their vapours give similar absorption spectra, whereas those of dissociable bodies differ considerably. Both these facts seem to support the view put forward by the authors.

An Account of Cauchy's Theory of Reflection and Refraction of Light. By Mr. James Walker, M.A. This paper is intended as a statement of the work previously done in the subject, and gives references to the original papers and "reproductions," &c., which will be of great value to persons studying this important branch of the "Theory of Optics."

Mr. Shelford Bidwell exhibited and described a voltaic cell in which the electrolyte is dry peroxide of lead. It consists of carefully dried peroxide placed between plates of lead and sodium, and gives a comparatively strong current, which passes from the sodium to the lead within the cell.

LEGAL INTELLIGENCE.

The Direct Spanish Telegraph Company (Limited) *ats* Bannatyne.

This was a petition heard before Mr. Justice Kay, in the Chancery Division of the High Court of Justice, on Saturday last, for the sanction of the Court to allow the company to reduce its capital in accordance with a special resolution passed on the 30th of September last, and confirmed at a subsequent extraordinary meeting held on the 19th of October. The resolution was as follows:—"That in consequence of the abandonment of the Company's original cable, the capital of the company be reduced from £190,000 (at present represented by 6,000 preference shares of £10 each, all issued and fully paid up, and 13,000 ordinary shares of £10 each, whereof 12,931 are issued and have £9 per share paid up, and 69 are unissued) to £95,000, and that such reduction be effected by writing off £5 per share from the amount credited as paid up on each issued share, and £5 per share from the nominal amount of each unissued share, the amount so written off the issued shares being capital not represented by available assets."

Readers of *The Electrician* will remember that in consequence of the passing of this resolution, Mr. Neil Bannatyne, who was at one time Chairman of the Company, and who attended both the meetings in question, and in company with one or two others recorded his vote against the resolution, applied for an injunction on behalf of himself and the other holders of preference shares, to restrain the Company, Sir James Anderson (its present Chairman), and the other Directors of the Company, from giving effect to that resolution.

The case was heard before Vice-Chancellor Bacon, and was fully reported in *The Electrician* of November 5th. The Vice-Chancellor having granted the injunction asked, an appeal was at once lodged, and the case was again heard before Lords Justices Cotton and Fry, and reported in our issue of the 12th and the 26th of November last. The result of that appeal was that the injunction granted by the Vice-Chancellor was disallowed, and the action was dismissed with costs. Hence the present application to Mr. Justice Kay to grant the confirmation order.

Mr. Rigby, Q.C., who appeared for the company at the previous trials, again attended in support of the application, which on this occasion was unopposed. The learned counsel at considerable length entered into the history of the circumstances which led to the necessity of the proposed reduction of the capital, and practically recapitulated his former arguments. He said that the application was perfectly *bonâ fide*

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and within the Act, because having lost £95,000, if the shareholders thought it in their interest, it was perfectly right to reduce the capital by that amount. It was the only possible way of reducing it, for there was no suggestion in the Act that they might reduce one part of the capital without making a corresponding reduction of the other. All the capital was part of the original capital, and whatever reduction took place with regard to one part must necessarily apply to the other. He could imagine that if this had been a case in which it could be shown that the proposed reduction was to be made at the expense of any section of the shareholders, there might be some objection to the granting of the petition. But it was not so. Moreover, the majority of the shareholders, both ordinary and preference, had, believing it to be for their interest, voted in favour of the resolution. On the whole case, therefore, he submitted that the Company brought itself within the terms of the Act, and that this was a case in which the Court might well exercise its discretion in granting the confirmation order. If his lordship took this view and granted the application, it was asked that the Company might have liberty to revert to their old form of title, and omit the words "and reduced" which had been used since the presentation of the petition. This could all the more easily be done since it was not a matter in which the creditors could be affected.

Mr. Justice KAY reserved judgment.

Yesterday morning Mr. Justice Kay delivered the following

JUDGMENT.

Mr. Justice KAY: The Court is asked to confirm a resolution for reduction of the capital of this Company.

The case is one in which creditors are not affected, because no capital is to be returned, nor is the liability of the shareholders to be diminished; but the Company, having sustained serious loss by the destruction of one of their submarine telegraph cables, desire to write off a portion of the paid-up capital on which they pay dividends, and thus to enable themselves to release part of a reserve fund which they have been forming, and which they now propose to apply in payment of the arrears due on the preference shares. The shares are preference shares of £10 each, fully paid up, and ordinary shares of the same nominal amount, on which only £9 has been paid. Dividends are paid not on the nominal amount, but upon the amount paid up on each.

In the Articles is a provision that the Company should have power by special resolution to reduce their capital or alter the amount and denomination of their shares. The preference shareholders having taken shares subject to this provision, it has been held in a litigation commenced by some of them to restrain the present proceeding for reduction, that it would not be contrary to the contract with them to do so—that they cannot maintain that there was an absolute bargain to divide among them an annuity equal to the total amount of the dividends on their paid-up capital, but that the contract was to pay to each £10 per cent. on such capital, subject to the liability that the capital might be reduced by proper proceedings for that purpose under the terms of the Articles.

The power given to the Court by Section 11 of the Companies Act, 1867, to confirm a resolution to reduce capital is a discretionary power—that is to say, the Court must exercise it, by confirming with or without conditions, or declining to confirm on a full consideration of all the circumstances. One matter to be taken into account is whether the proposed scheme would work injustice between the different classes of shareholders.

I agree that if the Court should think that would be the effect it would not be the function of the Court to impose conditions which would amount to an alteration of the scheme, but the proper course to take if such an alteration should be requisite would be simply to refuse to confirm the resolution, leaving it to the Company to prepare a new scheme if they thought fit.

Several cases of hardship and inequality as between shareholders were suggested. Suppose there were preference shareholders of £5 shares and ordinary shareholders of £10, all fully paid up, and the proposal was to write £5 off each share, that would totally extinguish the preference shares for the benefit of the ordinary shareholders.

If all the shares were £10 shares, but the preference were £5 paid and the ordinary £10, writing off £5 in that case would have the same effect until the rest of the capital were called up on the preference shares.

Again, if the proposal were to return capital to the shareholders, cases might arise involving questions as to whether the return should be in proportion to the nominal amount, or to the amount actually paid on each share. A return of capital in the winding up of a company may perhaps be hardly analogous, because then the liability for further calls is then taken away by dissolving the company. But upon consideration I do not think that the proposed reduction in this case will be unjust as between the shareholders. It is intended to write off £5 per share of the amount actually paid both on the preference and ordinary shares. As dividends are paid only on the amount paid up per share, this will reduce the dividend payable to the preference shareholders by a larger amount than that payable to the ordinary shareholders. That is to say, supposing the profits to be sufficient to pay 10 per cent. on all the capital paid up, the preference shareholder would be entitled to receive £1 per share, and the ordinary shareholder only 18s. By the reduction the preference shareholder would be deprived of 10s, leaving him 10s. per share, and the ordinary shareholder of 10s., leaving him 8s.

But unless an equal dividend had been paid on the preference and ordinary shares, which I understand has not been done in this case, the reduction may increase the chance of the ordinary shareholders receiving a dividend, or increase the amount per share which they may receive. The preference shareholders, no doubt, are induced to consent by the payment which is to be made of the arrears of their dividends. But this also will be an advantage to the ordinary shareholders, because in this Company I understand they are not entitled to anything until the arrears on the preference shares have been provided for.

The publicity which has been given to the matter by the litigation to which I have referred renders it unnecessary to continue the words "and reduced" as part of the name of the Company. There must be the usual advertisements in the *Gazette* and *Times* newspaper, and subject to this the Court confirms the resolution.

Mr. BEALE: The words "and reduced" are not to be put in.

Mr. Justice KAY: I have said so.

Mr. BEALE: I think the words of the Act confirm the reduction of capital. In this case is will not matter whichever way it is. Then will your Lordship approve of the amount for the advertisement. It is set out in paragraph 12 of the petition, and we ask the Court by the same order to approve that for the purposes of the Act of 1867 and 1877.

Mr. Justice KAY: It was stated to me that the shares were £9 paid up, but this states them as £4 paid up.

Mr. BEALE: That is after the reduction. £5 is wiped off.

Mr. Justice KAY: I should not understand the minute.

Mr. BEALE: The minute is to represent what the capital is after the reduction is confirmed by the Court.

Mr. Justice KAY: Which is the section of the Act.

Mr. BEALE: Section 15 of the Companies Act, 1867, and 4th section of the Act of 1877. The details were amplified by the 4th section of the Act of 1877. You were required to state a little more.

Mr. Justice KAY: Does this mean that the capital of the Company is reduced to £95,000?

Mr. BEALE: Yes.

Mr. Justice KAY: Then you should put in the words "as reduced"—that the capital of the fund as reduced is £95,000, in 19,000 shares of £5 each. Of the said shares 6,000 are preference shares, bearing a 10 per cent. preferential dividend, and all issued and fully paid up, 12,931 are ordinary shares issued and having £4 per share paid up, and the remaining 69 are ordinary shares remaining unissued.

Mr. BEALE: That is the detail required by the Act of 1877.

Mr. Justice KAY: But is that it?

Mr. BEALE: Yes, I have an affidavit verifying it.

Mr. Justice KAY: Then I will approve the amount as I altered it.

Mr. BEALE: If your lordship pleases—dispensing with the words "and reduced."

Edison and Swan United Electric Light Company v Woodhouse and Rawson.

This was an appeal of the defendants from the judgment of Mr. Justice Butt, for Mr. Justice North dated May 20th, 1886, which came on for hearing on Monday, before Lords Justices Cotton, Bowen, and Fry, in the Appeal Court.

Sir Horace Davey, Q.C., M.P., and Mr. McRory appeared for the appellants; the Attorney-General (Sir Richard Webster, Q.C., M.P.), Mr. Aston, Q.C., and Mr. Moulton, Q.C., representing the Company.

Sir HORACE DAVEY, in opening his case, explained that the part of the judgment complained of was so much of it as found for the plaintiffs, the Edison and Swan Company, on the ground of the patent having been infringed. The action was founded upon three patents—the Edison patent, which was the one now in question, and which was taken out on the 18th November, 1879, its number being 4,576; secondly, a patent originally taken out by a gentleman of the name of Swan, called the Swan patent; and, third, a patent taken out by a person named Gimingham, all the three patents being vested in the plaintiff companies, or some or one of them. The case as regarded Swan's and Gimingham's patents was abandoned by counsel in the course of the trial, and the only part of the case left, therefore, was that with regard to Edison's patent, the judgment providing for so much of the action as related to Swan and Gimingham's patents being dismissed with costs against the defendants. As to Edison's patent, the learned judge found that it was valid, and construed it in a particular way, and construing it in that particular way, it was not seriously disputed that the patent was infringed. The appellants from that judgment submitted to their lordships that the patent was not a good one, that it was not the proper subject matter for a patent. They said that the second claim, which was the one alleged to have been infringed, by giving it the construction which the learned judge put upon it, was too wide. If, on the other hand, the second claim was limited in a way which their lordships would appreciate, then they would say that there was no evidence of infringement. In fact, it was the old dilemma that so often arose in patent actions:—"If you construe a patent in such a way as to uphold it, then I do not infringe it; but if you construe it in such a way as to catch me in its meshes, then it is too large." Of course, when a patentee was endeavouring to uphold the validity of his patent, he was anxious to point out to the Court how extremely careful he had been to bring it within the limits of moderation; but, on the other hand, when he construed his patent for the purpose of catching an alleged infringer, he was anxious to show how large his sweep was, and how it included in its meshes the defendants in question. Having explained the difference between arc and incandescent lighting, the learned counsel proceeded to say that the scientific law relating to resistance might be expressed with sufficient accuracy by saying that the resistance, other things being equal, varied inversely to the sectional area of the medium or the burner, and directly to the length of the conductor—that was to say, the thinner they got their conductor the greater was the resistance, and the longer they got it the less was the resistance. That law was well known before the date of Edison's patent, which was not disputed. Having read Edison's final specification, the learned counsel said that the question which their lordships would really have to decide, assuming that

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they took the same view of the construction of that specification as the learned judge did, was, what was a filament? The witnesses differed very much in their ideas as to what was a filament; but they were all agreed that a filament did indicate a certain thinness or smallness of sectional area, and the question was, what thinness or what sectional area would make a filament? All that Edison said was that he had discovered that a fine cotton thread, properly carbonised and placed in a sealed glass bulb, exhausted to one-millionth of an atmosphere, would offer a certain amount of resistance; and he went on to show the advantages of that burner or thread being coiled as a spiral, because they were able to get a longer length into the bulb, which therefore offered a greater resistance; and being thus coiled, the whole of it did not act as a radiating surface. He then drew the attention of the Court to the method of manufacture described by Edison, and went on to say that if the pith and marrow of the invention, to adopt the favourite expression of his friend, Mr. Aston, was the discovery that the reduction of the size of the sectional area of the burner in an incandescent lamp gave it increased illuminating power, then he maintained that was not what was described in Edison's patent. He maintained that was too vague, and not proper subject matter of a patent, but was merely telling the world that a certain advantage was gained by reducing the size of a particular part of a well-known machine. He said, in fact, that this question of a filament was merely one of degree, and although Mr. Edison might have made a meritorious discovery, it was not one which constituted the subject matter of a patent.

The Court then adjourned.

On resuming his argument on Tuesday morning, Sir Horace Davey proceeded to read and comment upon the evidence of the witnesses given at the trial, and to draw the attention of the Court to the invention of King and Roberts respectively in 1845 and 1852, and said that the reason why the incandescent lamps of those inventors were not successful was that they could not get a sufficiently good vacuum. But by the invention of Sprengel's pump a better vacuum was obtained, and rendered possible the use of carbon lamps. It was not known that those lamps attained a commercial success, but it must be remembered, as had been stated by one of the witnesses at the trial, that incandescent lamps went out of favour chiefly owing to the fact of their not having been able to obtain a perfect vacuum, and to the great expense attending them, because at the time of day the process of generating a current of electricity by means of dynamos was not known. What had made electric lighting a great success was really the invention of the dynamo. In the year 1874 or 1875 Sprengel's pump was brought out, and became a part of the scientific knowledge of the world, and gave an impetus to the subject of incandescent lighting; and following upon that, in the year 1878, the attention of scientific men was directed to a patent (3,988) by Mr. Lane-Fox, which was extremely important, as it showed that it was part of the common stock of knowledge that, in order to obtain a successful lamp, they must reduce the sectional area of the burner. The great merit of Mr. Edison's patent was there explicitly stated. He then referred to three other patents taken out by Mr. Lane-Fox, and said that on reading the three specifications relating thereto they had an incandescent lamp, consisting of a glass bulb or receiver, and a bridge of any suitable material supported between two platinum wires, and they had also, on the face of the specifications, evidence that the patentee was aware that in order to make a useful lamp it was expedient to get a high resistance, and that he was also aware of the law by which that resistance was to be obtained. Therefore, he ventured to submit to their lordships that in all essential particulars Lane-Fox's invention included the lamp that Edison described. If Edison's lamp was a patent for a burner made in a particular way, then he did not say it was included, but if it was for all lamps in which the sectional area was small, then he submitted it was included. Again, before the date of Mr. Edison's patent, Mr. Swan, who afterwards made an offensive and defensive alliance with Mr. Edison, had directed his attention to the same subject, and had delivered three lectures—two at Newcastle on the 19th Dec., 1878, and the 4th Feb., 1879, and a third at Gateshead on the 13th March, 1879—in which he described a lamp (which was burned at the lectures) which contained the essential elements of Mr. Edison's patent, except that the carbon burner was what was described as a pencil of carbon, or as some of the witnesses termed it, a rod of carbon. There was no actual evidence as to the mode in which that was obtained, but the carbon burner was said to be by Sir Frederick Bramwell and Dr. Hopkinson, about $\frac{1}{25}$th of an inch in diameter, and it was said that that was not a carbon filament after the manner of Edison's patent; first, because the sectional area was comparatively speaking large, and second, that according to the witnesses the carbon pencil, from its appearance, appeared to have been cut and shaped out of a block of carbon, whereas it was said it was an essential feature of Edison's filament that it should be shaped before it was carbonised. Sir Frederick Bramwell (and, he believed, Sir Richard Webster, in his opening address, did) attached great importance to that as a feature of Mr. Edison's filament—that it was formed into a filament before it was carbonised, instead of being cut out of a material already existing in the form of carbon. In the Court below great stress was laid upon that point. If his learned friends were right in their construction of the patent, there was nothing which confined the claim to be carbon filaments which had been made into filaments before being carbonised, nor was there any particular mode pointed out in which the carbonisation was to take place. It was merely said to be in a closed vessel, which was well known before the date of Edison's patent. Edison did not confine himself to any particular shape of the filament, except as regarded the spiral, which was a particular application of it. They had, therefore, only to deal with the thinness or thickness and size of the burner. He had already anticipated to a certain extent what his point was. He asked the question the previous day, What was a filament? He then read the various definitions of the word given in the best known English and French dictionaries, as well as Rodgers's "Thesaurus," and proceeded to say that the opposite side maintained that a filament included the idea of flexibility and resilience. They also said it involved the idea of sectional area, What amount of sectional area he asked? It was surely the duty of the patentee to tell the world what it was that he claimed the monopoly of. If the description or the claim was so vague that people could not tell whether they were within or without that claim, he submitted that according to well known principles of patent law (which he intended to illustrate by reference to a few authorities) the patent was bad and invalid. It seemed to him that this was the material and crucial part of the case—what was a filament? His contention, as their lordships would by this time understand, was that it was a mere question of degree. To illustrate his case he would refer to King's invention again. King described a lamp with the best known vacuum that he had at the time, with a carbon burner or pencil in a glass receiver from which the air was exhausted. When Sprengel's pump was invented he had a right to use that instrument to get a better vacuum. He became acquainted with the law as stated by scientific men by which they could obtain a high resistance. Was he not at liberty to reduce the size of his burner to any extent that he pleased? Was a man at liberty if—Mr. Swan, he would suppose—in the course of his investigation he ascertained that if he reduced the size of his burner he would produce particular results—could a man go and forbid Mr. Swan, forbid Mr. King or Roberts, from reducing the size of his burner? If the whole patent was reduced to the substitution of a filament of a small sectional area for a small pencil or rod, he submitted that it was not proper subject matter of a patent. Having read the evidence elicited from Dr. Hopkinson in his examination, as well as that of Dr. Fleming, the learned counsel submitted that it went to show that it was entirely a matter of degree whether the burner was called a filament or not. If Edison had introduced the idea of flexibility and resistance into his definition of a filament there might have been something in the contention of his learned friends. But there was nothing of the kind spoken of. It was purely a matter of degree, which they could not define. Mr. Imray, who was also examined on the same point, gave similar testimony. He (Sir Horace Davey) would go further, and say they had proved that it was not a question capable of definition. Edison's specification gave no indication of size, except as regarded the putty wire to be formed into a spiral, and therefore it came to nothing more than this—a direction to adjust the size of the burner to the desired resistance, having regard to its length, of course, and the electromotive force, the patentee adding that, in his opinion, a high resistance would be found to give particular advantages. Now, if that was so, he submitted that that was nothing more than a statement of a well-known law, and a practical direction to persons to adjust the size of their burners to the required resistance, as King and Lane-Fox had previously announced in their publications. What, then, was the law on the subject? He would refer their lordships to a case where it was decided that a patent could not be obtained for a particular mode of using or a particular modification of an existing and well-known machine. The learned counsel then proceeded to argue that the claim of Edison was analogous to the case of Kay *v.* Marshall (8 House of Lords Reports), by which it was established by Lord Lyndhurst that a patent could not be obtained for modifying the dimensions in a part of a well known machine. In the face of that decision could Mr. Swan have been told, "You shall not reduce the size of your burner?" Could they have told Mr. King, "You shall not reduce the sectional area of your burner?" He ventured to submit not. He had pointed out in reading the specification of Mr. Lane-Fox and of Mr. King, that they pointed out to the world that persons must adjust the size of the wire so as to obtain the amount of resistance which it was desired to obtain for a lamp, having regard to the amount of the electromotive force. It was quite true that no one ever described that as a filament; but he ventured to submit that Swan's lamp, King's lamp, and that of Lane-Fox, being well known, they could not; and further, it being known what the law of resistance was—that was to say, that in order to produce a successful lamp the resistance must be adjusted—they could not take out a patent in the face of the action Kay *v.* Marshall, and say "I will protect and have a monopoly of this machine with a particular sized burner and a particular sectional area." The learned counsel next cited Ralston *v.* Smith (reported in the House of Lords cases, page 223) in further proof of his contention, and went on to observe that there was nothing new in Edison's lamp in the second claim in regard to the mode in which it was worked. It was a lamp like Mr. Swan's or King's by which the light was produced by passing an electric current through wires sealed in a glass receiver; the maufacture was exactly the same in each, and the use which was made of the various parts of the combination which went to make up the lamp was precisely the same in each. What was the difference then? That Mr. Edison supposed himself to have discovered—which he (the speaker) would assume for the purpose of argument that he did discover—that a particular sized carbon burner would give a particular beneficial effect. That was no new process of manufacture. The principle on which the lamp acted and the light was obtained was in every respect the same. It was only a particular use—or rather, he ought to say, the most beneficial mode in which a well-known machine could be used. In other words, it was nothing more than this, that the patentee told Mr. Swan, for example, who had used these incandescent lamps before the date of Edison's patent, "You shall not be allowed to reduce the size of your burner, because I think that that reduction will give you particular beneficial results."

Lord Justice FRY: You say that it is only a new mode of using an old machine.

Sir HORACE DAVEY said that was his contention. The case of Paterson *v.* the Gas Light and Coke Company (2 Chancery Div. Reports, p. 812) was next referred to, and the learned counsel contended that, although there

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was some distinction in that case, inasmuch as there was no alteration of the machinery but only in the way of working it, the reasons given by Lord Justice James, in deciding it, applied with equal force and cogency to the present case. He also quoted the decision of Lord Chelmsford in Harrison *v.* the Andertown Foundry (1 Appeal Cases, p. 581), and asked whether, having regard to the evidence before their lordships, it was possible to say that the second claim, interpreted as it had been by the Court below, did define and limit precisely that which was claimed to have been invented, and, therefore, patented? He was willing to rest his case upon that test. He now desired to call their lordships' attention to a part of the evidence which he thought went directly to the root of the matter, and that was this. Supposing his learned friends were right in saying that the great merit of Mr. Edison's invention was that his filament was shaped before it was carbonised. There was conclusive evidence to show that that was not new at the date of Mr. Edison's patent, and that a French gentleman named Sidot had written a paper, which was published in England, in which there was described a mode of carbonising filaments of thread and splints of wood and other things, and which went on to say that those threads and splints of wood, when carbonised, would be useful for electric lighting. Extracts from the paper in question having been read, Sir Horace Davey pointed out that his learned friends at the trial tried to get rid of that difficulty by saying that Sidot referred to arc lighting. But Sidot spoke, as their lordships would observe, of a piece of carbon becoming gradually incandescent. It might be that Sidot meant to include both kinds of electric lighting; but that was not the point. What he wished to insist on was this, that in Sidot's paper they had a description which might lead persons towards using carbonised thread, hemp, and splints of wood for the purpose of electric lighting. What was to prevent Mr. Swan, for instance, from carbonising a piece of thread or wood in the manner pointed out by Sidot, and substituting it for the carbon pencil in his lamps? Were they to deprive a man of the right of using in a machine which he had the right of using the best materials which were known at the time? And yet their lordships would see that this patent, in the sense in which the other side supported it, would prevent all the gentlemen whom he had named from making use of the various discoveries which were useful for the purposes of the machine which they already possessed. Commenting on Prof. Dewar's evidence as to experiments which he had made on Sidot's instructions to obtain the results claimed, the learned counsel ventured to describe it, as he had done in the Court below, as a signal example of trying how not to do it, because in cross-examination it was elicited from Prof. Dewar that he had disobeyed every one of Sidot's directions, and, consequently, had not obtained Sidot's results. Prof. Dewar did, as a matter of fact, everything which was necessary to make the experiments a failure. He then proceeded to read the evidence given in the lower Court upon the subject of the spiral, which Edison claimed not as a spiral in his lamp but as a claim *per se*, and submitted that it was a claim of something which was known before the date of Edison's patent, as was fully borne out by the patents of Van Choate and Pulvermacher taken out about the year 1878, the specifications of which were read at length. He submitted that those specifications were a description of a spiral of the size necessary to give the desired amount of resistance, and therefore included all sizes, consisting, it might be, of carbon, platinum, mica, asbestos, or any other combination, the mode described of making the spiral being identical with one of the methods described by Edison himself.

The Court then rose

On resuming on Wednesday morning, Sir Horace Davey proceeded to analyse the evidence of some of the chief witnesses at the trial, and concluded by reading the judgment of Mr. Justice Butt.

Mr. ASTON, Q.C., in the absence of the Attorney-General, opened the case for the respondents. He said that if there was one thing that he thought had been made more clear to their lordships than another, both from the reading of the judgment of the learned judge and from the address of Sir Horace Davey, it was that prior to the date of Edison's patent there was no good practical working incandescent lamp. It was very true that their lordships had had their attention called to various attempts that were made prior to the date of Edison's patent of 1879 by persons of great ingenuity and thoroughly acquainted with all the requirements of people who wanted electric lamps. There was a long list of them, from King down to Lane-Fox. The learned counsel then detailed the desiderata of an incandescent lamp, and said that down to the 10th of November, 1879, the chief problem how to use in an incandescent lamp a material whose molecules were of such a character, and which were so physically connected together as to allow them to have the necessary amplitude of vibration which would cause intense light, and yet, at the same time, would prevent the destruction which would follow from the particles being made to vibrate with that intensity, was unknown. It was no doubt known to King and others that carbon was a good material, and it was attempted to use it in a variety of forms. But in all those cases there seemed to have been something which everyone missed, which was a distinct essential, namely, something which would put it in such a condition that the disruption of the form of the carbon when used should be prevented. Referring to the discoveries of Mr. Lane-Fox, he went on to say that that gentleman, when he got as far as his discovery of the metallic wire, was on the threshold of Edison's invention. But he must call the attention of the Court to this important fact, that the filament of Edison's lamp was raised to a heat of something like 2,000 centigrade when the lamp was in full glow. There therefore took place, as might be imagined, an elongation of the filament itself, and a disturbance of the particles would have to be provided for. If they took the platinum wire recommended by Lane-Fox, they had the necessary expansion and contraction provided for, but there were other inconveniences attaching to the use of a metallic wire, which, as a matter of fact in the case of Lane-Fox's lamp, resulted in failure. The ultimate outcome of all that Lane-Fox had done, according to Sir Frederick Bramwell, was that he had constructed what was called his luminous bridge, which remained in the state of an attempt never carried into effect, as far as was known, and as to which their lordships had not a particle of evidence. They would bear in mind what Dr. Hopkinson said, that there must be in a filament resiliency and flexibility in order to provide against alternations of heat and shock, and he further said: "I do not know how that can be attained, unless the filaments are made as Edison tells you how to make them." So also the desiderata which were required up to the date of Edison's patent were not found in Swan's lamp, which he would show was an entire failure.

The Court then adjourned.

On resuming his argument on Thursday morning, Mr. ASTON referred to an account given by Mr. Swan himself, reported in the *Transactions* of the Newcastle-on-Tyne Chemical Society, and the observation he founded upon that was that Mr. Swan, who had come nearest of all persons to the discovery of Edison, had failed to see the cause of the want of practical utility in his lamp, or that he used a carbon-rod instead of a filament. It never occurred to him to say that he got disruption because he got his carbon in a wrong physical shape or form. It was when Edison applied the filament in a proper form that the incandescent lamp was for the first time an accomplished reality. He then pointed out that the dynamo machine and the Sprengel pump had been available for many years before the date of the patent. Having read the specifications of Van Choate, and extracts from M. Sidot's paper, the learned counsel ventured to submit to the Court that if Edison's specifications were construed by the light of the evidence, it would be found they were entitled to claim for a specific incandescent lamp having the elements constructed as described; and a combination with a filament not made with metal but of carbon, and put in an exhausted receiver through which sealed conducting wires were passed; and a claim to a specific spiral arranged in a specific manner like to nothing which had appeared before.

The ATTORNEY-GENERAL then took up the case and said that their lordships would find that it was conceded by the defendants' witnesses when he came to read certain passages of their evidence that the combination which Mr. Aston had just described was absolutely new. This was the case which he was going to prove out of the mouth of every witness who had been called in the case. He would not stop now to refer to Ralston *v.* Smith and Kay *v.* Marshall, as their lordships would find when he came to consider them, that they were cases of claims to make the subject matter of a patent the using of an old machine in a new way. There was a broad line of distinction, as Lord Esher in more than one case pointed out, between a new commercial article — meaning a new manufacture in the sense of being a concrete product — and a new mode of applying an old machine, or old ingredient. It was conceded by every witness that whereas prior to the date of the publication of the complete specification of Edison, incandescent lamps were absolute failures—were commercially unknown—from that time they were uniformly and universally a success. Their lordships were perfectly entitled to say to him "that will not help you to construe the specification, unless the specification admits the construction that you are contending for." But in view of the inference to be drawn from the evidence, he would ask their lordships to find that an admission was made and acceded to by Sir Horace Davey and Mr. Charles, and was amply well founded, that the specification contained perfectly sufficient instructions to enable a competent workman to make the incandescent lamp therein described, and that everything that had happened since had been an improvement on that incandescent lamp, and not a different lamp. What was the invention? It was this, that Mr. Edison, for the first time, found that they could rely upon carbon threads alone to have sufficient characteristics for the purpose of electric lighting. He found that for incandescent lighting they could rely upon the strength, the toughness, the resistance, the resilience (if it were material), the flexibility, and whatever was essential to make a successful electric light, that they could rely upon carbon alone in the shape of a thread, and made into a thread before it had been carbonised. It was impossible to overestimate the importance of that discovery, whether it were regarded from a scientific or commercial point of view. Up to that time the course of discovery had been leading people wrong for 20 or 30 years. It had been known for a considerable time that carbon would act as a conductor or illuminating medium in electric lighting, but it had never entered into the mind of anybody that they could rely for practical electric lighting upon a thing so thin and fragile (and yet having the properties which made it successful) as a carbon filament which, if it were taken out of the lamp, would break in one's hands, so exceedingly delicate was it in manufacture. The latest exponents, including Mr. Swan himself, had proceeded on lines which showed how little real knowledge they had, great as their knowledge was, and great as their experience had been, as to where the keynote of the whole secret lay. Knowing that carbon was a proper and useful conductor, as a medium through which the electricity could pass, and the light radiate, Swan was possessed with an idea that it was not strong enough, and, accordingly, having got a proper proportion of carbon in his conductor to pass the current, the strength of which could be measured to the greatest nicety, he proceeded to build up the strength of that conductor by non-conducting *media*. He took a stick of carbon—a thing rigid in itself—and tried to work it down to a sufficient small cross-section to get the proper resistance in the circuit. When they were approaching this argument they had simply to consider what was the previous knowledge of people on the subject. The whole of that knowledge might be divided into two classes—the knowledge of the people who, having got carbon in the shape of a powder or pulverised substance, built up a bridge in which carbon formed the conducting element, or of those who took a stick of carbon and endeavoured to work it down to something that would act effectively. Edison had in

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his specification described that which was absolutely new, and in terms that no workman could mistake. It was an entirely different question whether the specification was sufficient to enable them to make the article, and whether the claim did or did not accurately describe what was the sort of combination to be protected. He was not there to say whether his clients could make as good a lamp as Messrs. Woodhouse and Rawson. Possibly the latter might make now a better lamp than the former. But his point was, and he challenged his learned friends to put their case higher than this, that they had made a better combination—that was to say, that they had made a better preparation of one of the elements of the combination, which was not described within the specification of the second claim of Mr. Edison. If carbon filaments were old, and he described five or six, though, of course, he could not pretend to exhaust them all, he could equally urge before their lordships that his learned friends could not get away from the meaning of the specification by saying "We have used an old carbon filament which is not the same as you have described, but which we have put in for the purpose of making a distinction"—because the patentee was entitled to claim "a glass receiver with a carbon filament through which the leading wires pass, the air having been exhausted in order to produce a vacuum." If his learned friend could have got up in court and said that it was not a carbon filament at all, the case would have been very different. His clients must have been beaten. But he respectfully urged upon their lordships that the extraordinary merit of Edison's invention was the simplicity of the combination, starting from a state of knowledge which would not have led people to the discovery, and announcing a genus of the widest description; and the merit of it was the wide description, which made it of necessity an infringement on the part of anyone, even if he could get hold of a better carbon, but still a carbon filament. If, too, his learned friends could have said, "Your description is bad, because there are numbers of carbon filaments made as you describe it, and it will not work"—if they could have said that a patent like yours could not make a working lamp—he admitted that it would have been very embarrassing. But when, on the contrary, he could say in his argument for the second claim that it was the only working lamp which had ever been made, he submitted that he made good the claim. He went further, and said that no diminution of sectional area would produce Edison's invention, starting from the point which Swan reached. On his instructions and on the evidence he did not believe that a carbon filament could be produced which would at all answer unless that filament were made before it was carbonised. The learned counsel then proceeded to define the meaning of a filament and to analyse the evidence upon the point when the Court rose.

In re the Pilsen Joel and General Electric Lighting Company.

This was a petition, heard before Mr. Justice North last Saturday, for the confirmation of resolutions for the reduction of capital lost or not represented by available assets. The capital of the company had been reduced on a former occasion, and as then reduced was represented by 100 £4 shares, fully paid up, and 28,000 £3 shares, £2. 5s. paid up. It was now proposed that £1. 15s should be written off the £4 shares, and £1 off the £3 shares, reducing them to £2 shares, with £1. 5s. paid up.

His LORDSHIP confirmed the reduction, directing the use of the words "and reduced" for a month.

Mr. Higgins, Q.C., and Mr. Rawson appeared in the matter.

COMPANIES' MEETINGS.

River Plate Telephone and Electric Light Company (Limited).

An extraordinary general meeting of this Company was held yesterday at the offices, 34, Walbrook, when the subjoined resolutions, which were passed at the meeting on the 1st inst., were submitted for confirmation as special resolutions :—

"1.—That it is expedient to effect an amalgamation of this Company, except as regards its Uruguay business, with the United Telephone Company of the River Plate (Limited), and that with a view thereto this Company be wound up voluntarily under the provisions of the Companies Acts, 1862 to 1883."

"2.—That Thomas Lloyd, of 34, Walbrook, E.C., Esq., and Charles Lionel Wingfield FitzGerald, of No. 4, Hercules-passage, E.C., Esq., be, and they are hereby, appointed liquidators for the purposes of such winding up, at a remuneration to be fixed by the Company."

"3.—That there be conferred upon the liquidators all the powers which can be conferred upon liquidators, under the provisions of the Companies Acts, and that they shall have the assistance of a consultative committee, consisting of Mr. Arthur Baker and Mr. William Cuthbert Quilter, with power to add one to their number."

"4.—That the remuneration of the liquidators be £250 each."

"5.—That the agreement expressed to be made between the Company of the first part; the United Telephone Company, of the River Plate, of the second part; Richard Rodgers, on behalf of the United River Plate Telephone Company (Limited), which is about to be incorporated, of the third part; the Consolidated Telephone Construction and Maintenance Company (Limited), of the fourth part; and Frank Williams Jones of the fifth part, be, and the same is hereby, approved, and that the liquidators be, and they are hereby, directed to adopt the said agreement on behalf of the Company, and to carry the same into effect, with power to agree to such modifications in the Articles of Association of the new Company as they think fit."

The SECRETARY (Mr. R. Rodgers) read the notice convening the meeting as above, and the minutes of the last meeting were taken as read, confirmed by the present meeting, and signed as correct by the Chairman.

The CHAIRMAN: Gentlemen, you have heard the notice calling the meeting, but before I proceed to move the several resolutions, I should like to state—what, perhaps, ought to have been stated at the last meeting, though I forgot to do so—that about two months ago Mr. Quilter and some friends of his acquired 7,000 shares in this Company, 5,000 of them being sold by the Company. Having stated so much, I do not think it is necessary to occupy your time, and therefore, without further preface, I will propose the first resolution (which he read).

Major FITZGERALD seconded the motion.

The CHAIRMAN asked if any shareholder wished to say anything. Receiving no response, he put the resolution and declared it carried unanimously. Continuing, he proposed the second resolution.

Mr. R. E. BATEMAN seconded the motion, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Major FITZGERALD, the third resolution was carried unanimously; as were also the fourth and fifth resolutions, which were proposed by the CHAIRMAN and seconded by Mr. BATEMAN.

Mr. C. L. W. FITZGERALD then proposed a cordial vote of thanks to the Directors for the way in which they had carried the amalgamation through, and also to the officers of the Company. Mr. Rodgers, in this country, and Mr. E. F. Powers, and the officers abroad, had, he was sure, done the best for the Company, and the sharedolders ought to give all those gentlemen a very hearty vote of thanks.

The motion was seconded and carried unanimously.

The CHAIRMAN: In the name of the Board I beg to tender you my grateful thanks for the kind manner in which Mr. FitzGerald has proposed the vote of thanks to us, and the cordial way in which you have carried it. As a Director, and for a short time Chairman of the Company, I can cordially confirm everything that Mr. FitzGerald has said respecting the very zealous and able manner in which Mr. Rodgers and our employés in the River Plate have carried out all their duties, and worked in the interest of the shareholders.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	Closing Prices. Dec. 15.		Business Done Week Ending Dec. 15. Highest.	Lowest.
Anglo-American	36,	37	36¾	36¼
Do. Preferred	59½,	60½	60½	58¾
Do. Deferred	13½,	14¼	14¼	13¾
Brazilian Submarine	10⅞,	11⅛	11⅛	11 1-16
Cuba	11,	11½	11¼	—
Do. Preference	18,	19	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Preference	9,	10	—	—
Direct United States Cable	9⅜,	9⅝	9⅝	—
Eastern Telegraph	10¼,	10¾	10½	10¼
Do. 6 per Cent. Preference	13½,	14	13⅞	13¾
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	10¾,	10⅞	10 13-16	10¾
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	5⅛,	5⅜	5¼	5⅛
Do. Preference	12⅛,	12⅜	12⅜	12 5-16
Great Northern	13⅜,	13⅝	13½	13 7-16
Indo-European	34,	35	—	—
Reuter's	7,	7½	—	—
Submarine	190,	200	195	194
West India and Panama	¾,	1	—	—
*Do. 1st Preference	8¾,	9¼	—	—
Western Brazilian	7⅛,	7⅜	7 5-16	7 3-16
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

* xd. 8s., on account of arrears.

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	⅝	—	—
Oriental	3-16	5-16	—	—
United Telephone	13⅜,	13⅝	13⅝	13⅝ xd.

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	2 15-16	2¾
Do. (fully paid)	4½,	5	4½	—
Swan	1½,	1¾	1 11-16	1
Maxim Weston	5-16,	7-16	⅜	—

MISCELLANEOUS.

Telegraph Construction	39	40	40	39½
India Rubber, Gutta Percha, and Telegraph Works	24	25	24½	—

TRAFFIC RECEIPTS FOR NOVEMBER, 1886

COMPANIES.	Nov., 1886.	Nov., 1885.	Increase.	Decrease.
Cuba Submarine	2,550	2,313	237	—
Direct Spanish Telegraph	1,860	2,032	—	172
Eastern Extension	36,739	40,427	—	3,688
Eastern Telegraph	50,817	56,245	—	5,428
Great Northern	21,200	—	—	—
West Coast of America	4,190	—	—	—

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NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 17th inst. amounted to £4,665.

Okehampton.—At Okehampton, a small town on the borders of Dartmoor, a cabinet maker has lit up his premises with forty 20 candle-power lamps, motive power being derived from a turbine placed in the River Oke.

West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half-month ended the 15th December, are £2,278, as compared with £2,504 in the corresponding period of 1885.

Milan.—It is stated that Commander Carlo Erba, a well known Italian chemist, has given the sum of 400,000 francs for the foundation of a school of electricity, to be erected in the neighbourhood of the Institute of Technics at Milan.

Books Received.—From Mr. Thos. Murby we have received a copy of "The Arithmetic of Electrical Measurements, with Numerous Examples," by W. R. P. Hobbs, head schoolmaster of the Naval Torpedo School, Portsmouth.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending December 17th, 1886, were £3,856, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

The Lighting of the Streets of London.—We remark, with a certain inward satisfaction, that the columns of the daily press once more contain strongly—but not too strongly—worded complaints against the miserable inefficiency of the lighting in the London streets.

The Electric Transport of Force.—We learn from the *Bulletin des Sociétés d'Electricité* the MM. Rothschild are about to float a company with the object of carrying out the electric transport of force on methods recently shown by M. Deprez at Creil upon a commercial basis.

"Theory of Magnetic Measurements."—Prof. Nigher's book on the "Theory of Magnetic Measurements, with an Appendix on the Method of Least Squares," a notice of which appeared in our last week's issue, is published in this country by Messrs. Whittaker and Co., Paternoster-square.

Telephonic Extensions.—The South of England Telephone Company have effected telephonic communication between Northampton and Granville.—At Nottingham the National Telephone Company have opened a number of call offices, at which 3d. is charged for three minutes' conversation.

Long-Distance Telephony.—The telephone line between New York and Philadelphia is now in successful operation. At present 24 heavy copper wires are in use, but provision has been made for 70 wires. The tariff is fixed at $300 per month—say £1,750 per annum—and more lines are already required.

Eastern Telegraph Company.—The Eastern and South African Telegraph Company (Limited) notify that the coupons and interest warrants due on 1st January next, on their Five per Cent. Mortgage Debentures, will be paid on and after that date at the Banking House of Messrs. Barclay, Bevan, and Co., 54, Lombard-street. Coupons should be left three clear days for examination.

Lecture at Norwood.—A lecture was recently delivered by Mr. W. Lant Carpenter before a working class audience at Norwood, upon "Electrical Energy and its Uses," under the auspices of the Norwood Literature, Science, and Art Society. There was a crowded attendance, and the lecture, which was illustrated with numerous experiments, was followed with great attention throughout.

Electric Light for Pearl Fishing.—The steam yacht "Chic," belonging to Messrs. Alley and Maclelland, engineers, Glasgow, has been fitted up with a Brush dynamo for the purpose of suiting her for the pearl fishing in South Australian waters. The vessels at present there can only light up a depth of seven or eight fathoms, but it is anticipated that the "Chic" will be able to light up at seventeen fathoms.

Statistics of the Telephone in Europe.—The following figures, showing the present position of the telephone upon the Continent, have been published. Germany (State lines) 11,800 subscribers, average rental about £10; Italy, 8,590 subscribers; France, 7,000; Switzerland, 4,170; Belgium, 3,280; Spain, 800. The figures for our own country are not immediately available; probably, however, we should make a good second, even if we did not head the list.

The Lighting of Leamington.—We understand that the Leamington Town Council have accepted an offer from Mr. Arthur Chamberlain, of Birmingham, to light the town with incandescent electric light, at a cost of from 20 to 30 per cent. more than gas. Mr. Chamberlain proposes to lay in a temporary installation to illuminate the Parade and the principal public buildings with electricity during the celebration of the Queen's Jubilee.

Tender for Lighting Wanted.—The Gloucester Waggon Company invite tenders for the best and most economical mode of lighting one of their new workshops. Proposals may be for lighting by gas, electricity, or otherwise, and may include also methods applicable to raising steam and to heating iron rivets. Proposals to be delivered by the 18th January to the general manager at Gloucester, from whom further particulars can be ascertained.

Electric Lighting in Europe.—The Sociedad Electro-Dinamica are about to establish a central lighting station at the town of Chulilas, where a water power to the extent of 2,930 horse-power is available. They also talk of transmitting power to Valence, a distance of 56 kilometres.—The port of Kiel is to be provided with electric light; the installation will be carried out by Messrs. Schuckert, of Nuremberg.—In France a small town called St. Hilaire du Harcourt is to have a central lighting station.

Temporary Installation.—At the dance given at Mr. J. Bergthiel's house, 38, Warwick-road, W., on Wednesday, the 1st inst., the rooms were illuminated by 21 Woodhouse and Rawson incandescent lamps, the current being supplied from accumulators placed in the garden close by. The lamps were fitted in artistic shades, suspended by means of flexible conductors from the leads, which were stretched down the lengths of the rooms and covered with foliage and flowers. The work was done by Mr. Arthur Bergthiel, of Messrs. Woodhouse and Rawson.

Competition in Telegraphy.—The Postmaster-General, in reply to a deputation from the London Chamber of Commerce, among other things, referred to competition in cable work as tending to cheapen tariffs. Now, the head of the greatest monopoly that ever existed is hardly the person to talk in this strain. Either Mr. Raikes knows that, commercially, competition in the case of cables is another word for loss of capital or is he ignorant of the fact. If the latter, the sooner he obtains some elementary information on the subject the better.

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THE BOSTON (U.S.) CENTRAL LIGHTING STATION.—We gave last week an interesting diagram showing the hourly consumption of current from this station. We may add that the plant, which at present has a capacity of rather less than 10,000 sixteen candle-power lamps, will shortly be increased to 40,000, when it will probably be the largest central station in existence. The new building will cover an area of 58ft. by 85ft., and will be two stories in height with a possibility of being raised to five stories. It will contain fourteen boilers and twenty engines.

WHISPERS IN THE LAW COURTS.—*Scene*—The Appeal Court. Lord Justice of Appeal (to Eminent Counsel): Do you mean that Van Choate's carbon was to be used for arc lamps and not for incandescent lamps? Eminent Counsel: For arc lamps, I think, my lord, but I am not quite certain. (Hurried consultation of bar. Second Eminent counsel to First Ditto, in whisper: Van Choate's carbon was for incandescent lamp without a globe, but *you'd better say arc lamps.*) Eminent Counsel: I find, my lord, that it *was* for arc lamps. (Left speaking.)

THE ADVANTAGES OF ELECTRIC POWER FOR MILLINERS' SHOPS.—Practical experience in the United States is said to have shown that a greater amount of work is accomplished by sewing machines when run by electric motors than by foot-power. Not only can the work be done with a higher speed of the machine, but considerable time wasted in bringing the machine up to full speed by the use of foot-power is saved. Less repairs are required, for the irregularity of the foot motion is destructive to the adjustment of the more delicate parts of sewing machines.

THE COST OF ELECTRIC LIGHTING IN AUSTRIA.—In a paper read before the Vienna Society of Electricians, Mr. F. Ross gave some figures showing the actual working cost of the electric light in certain theatres, where it has been in use for a sufficiently long period for a definite estimate to be formed. The prices quoted exhibited extreme variations; for instance, at Carlsbad, where the motive-power is obtained from a gas engine, 1,000 ampere-hours at 100 volts costs 54s., while at Bruun, with steam-power, the cost is only 18s. At Prague, also with steam-power, the cost is 26s.

THE PARIS-BRUSSELS TELEPHONE LINE.—It is announced that the Belgian Government (very sensibly in our opinion) no longer insist upon the adoption of the Van Rysselberghe system for this line, which will therefore consist of a complete metallic circuit of siliciun (or phosphor) bronze. On the other hand, the Belgian authorities have proposed the employment of the mixed system for the line which is projected between Verviers and Cologne, and the Germans are following the French example, and intimate their preference for a telephone circuit pure and simple for work of this description.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The Council of the Society of Telegraph-Engineers and Electricians have awarded the premiums at their disposal for the papers read during the past session as follows:—The Society's premium, value £10, to Mr. Alexander Bernstein, for his paper "On Low Resistance of Glow Lamps"; the Paris Exhibition premium, value £5, to Captain Sankey, R.E., for his paper "On the Electrolytic Deposition of Copper"; and the Fahie premium, value £5, to Mr. H. Kingsford, for his paper "On the Localisation of Faults in Submarine Cables."

LECTURE ON THE DEPOSITION OF DUST BY ELECTRICITY.—At the Bristol Naturalists' Society, a paper was recently read by Mr. W. P. Mendham, on the deposition of dust and smoke by electricity. A description was given of the process, which was suggested by Dr. O. Lodge, and is now employed with considerable success for causing the rapid deposition of the fumes of sublimated lead, by means of the action of powerful Holtz or Wimshurst machines. In the discussion which ensued, it was pointed out that the process was not adapted for use in depositing either coal dust in mines or flour in mills, on account of the danger of explosion.

LIGHTNING CONDUCTORS.—The Minister of Public Instruction of the French Government has recently submitted to the Academy a series of questions with regard to the precautions which should be taken for the protection of buildings from lightning, particularly in the case of buildings which are roofed with metal. As might have been anticipated, the reply of the Academy was to the effect that all such masses of metal should be carefully connected with the conductors, that for extensive buildings several conductors should be affixed at different points, and that it was above all things necessary to see that the conductors make thoroughly good earth connection.

THE WOODHOUSE AND RAWSON MANUFACTURING COMPANY'S EMPLOYÉS' ANNUAL DINNER.—The third annual dinner of the *employés* of the Woodhouse and Rawson Electrical Manufacturing Company was held at the First Avenue Hotel on Saturday evening, when the chair was taken by Mr. Rawson. A very pleasant evening was spent by all present, the musical portion of the entertainment being far above the standard of merit which is usually attained on such festive occasions. Mr. Woodhouse had not yet sufficiently recovered from his recent severe illness to enable him to take part in the proceedings; but we are glad to be able to state that he is now very much better, and it may be hoped that his health will shortly be fully restored.

A LARGE EDISON MACHINE.—The French Edison Company have just completed, in their factory at Ivry, the construction of an Edison dynamo, to give 1,000 amperes and 125 volts at 350 revolutions. The machine is intended for lighting the stage of the Paris Opera House; and floor space being limited some considerable modifications have been made in their usual design. The armature rotates between two pairs of field-magnets set vertically so as to give consequent poles. The machine is purely shunt wound, and a field current of only 25 amperes gives an induction of 5,000 C.-G.-S. units. The full current of 1,000 amperes is taken off by three pairs of brushes. Although the weight of the machine is nearly 10 tons, it is mounted upon a slide bed. The preliminary trials are said to have been very satisfactory.

FRANCO-GERMAN URBANITIES.—The following incident, which has recently been the subject of comment in the columns of the French scientific press, is a little amusing. At the close of a series of articles in a certain electrical journal there appeared a paragraph eulogising the general excellence of design and workmanship of the scientific instruments made in Germany. A leading firm immediately writes to express their extreme astonishment, and that of all persons to whom they have shown the article, that it should be possible for statements so "unpatriotic" to appear in a French journal; while another writer roundly asserts that German instruments cannot bear a moment's comparison with those manufactured in France. Moreover, they are—according to this authority—never of original design, being always copied either from French or English makers.

PROPOSED CENTRAL STATION WITH TRANSFORMERS AT RHEIMS.—A number of isolated installations of electric light already exist at Rheims, most of which obtain motive power from engines already in use for other purposes. With proper precautions such arrangements can, as a general rule, be made to work very well indeed, but for some reason or other the good

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people of Rheims do not seem to be quite satisfied with their present arrangements. Or perhaps it may be nearer the mark to suppose that having experienced the advantage of the electric light for themselves they are anxious to extend it to their neighbours. Anyhow, a movement has been set on foot in the town, and is being warmly supported by the present owners of isolated installations, for the establishment of a central lighting station. It is at present intended to make use of transformers, which, in the opinion of the *Bulletin Internationale de l'Electricité*, "assuredly furnish the true solution of the electric lighting of towns."

"Dynamo" Telephones.—Prof. Silvanus Thompson pointed out some time ago that in all probability the most successful solution of the problem of long-distance telephony, and also that of overcoming inductive disturbance, would result from the discovery or invention of a method which would enable us to employ a current many hundreds or even thousands of times stronger than those at present used in telephony. Prof. Thompson has recently constructed some remarkable instruments with a view to carrying out this idea. We shall hope shortly to give further details with regard to the performance and construction of these instruments; in the meantime we may say that they are based upon the idea of utilising an armature constructed very much after the pattern of the armature of a dynamo (either of the ring or drum type), and mounted between field-magnets. Instead of being capable of rotation it is, however, supported upon an elastic axle, which permits it to vibrate to and fro over a small arc. To a point upon the periphery of the armature is affixed a pivoted bar, the other end being attached to the centre of a diaphragm.

The Lighting of Trains.—"The evening traveller upon certain of our railways," says the *Pall Mall*, "is apt to think of Milton, not as a poet, but as a prophet: 'Yet from these flames no light, but rather darkness visible.' Nothing radical in the shape of reform, travellers may depend upon it, will ever be attempted by these very conservative companies until the regular passengers take to holding indignation meetings on the departure platforms at our great metropolitan stations. There is sufficient of novelty in this suggestion to ensure for such demonstration a great success. Who will lead the way?" The experiments which have been carried on since March last on the Lille and Brussels lines with a bichromate battery are said to have proved perfectly successful. The cars from Paris to Brussels can make five journeys in each direction, averaging a lighting period of seven hours, before recharging is required. This is said to occupy only five minutes, though we should scarcely like to guarantee the accuracy of the statement. What, however, is more important is the price. This is given as *1·1fr. per candle-power per hour*. For the sake of the inventor we shall hope that this ought to read "per lamp-hour of twenty candles."

An "Open" Incandescent Lamp.—Messrs. Lyman and Wheeler, of Washington, have introduced a somewhat novel form of incandescent lamp, which may perhaps have an important future. The idea is not altogether new, for it is in reality a "Lampe Soleil," adapted for use upon the scale of incandescent rather than arc lighting. The arrangement may be briefly described as consisting of a shallow cup of refractory material, having a tube of the same substance projecting on either side. The cup is filled with amorphous zirconia (or other similar substance), and a platinum wire passing through either tube almost makes contact in the centre. When a current is passed through, the zirconia is raised to a white heat—but how the current is induced to start we are not told. The idea is to have the lamp close under the ceiling, and diffuse the light from a whitened reflector, so that the actual incandescence is concealed from the eye. This is undoubtedly the principle upon which artificial light ought always to be supplied, if it can be done. We shall be very glad to hear that the device proves sufficiently practicable and economical for general service, but we fear that there are serious difficulties to be overcome before this can be accomplished.

The "Union" Storage Battery.—From *The Times* of Saturday last we learn that a new battery has appeared under the name of the "Union" storage battery. We gather that this cell belongs to the class which lies upon the somewhat ill-defined border line between primary and secondary cells. That is to say, it is proposed to remove the exhausted plates from the cells and cast them away for re-charging. We know no essential reason why such a system should not eventually become a thorough commercial success. But as it is obvious that it can scarcely be made to pay until a considerable number of subscribers have been secured, it is to be feared that such success may be some time in coming. As we have not had an opportuntiy to inspect this battery on our own account we can only record such particulars as are to be gathered from *The Times* paragraph. Of these the only important statements are that a cell of thirteen plates, measuring (externally) 11in. by 7in. by 6in., weighs 2·0lbs., and has a capacity of 115 ampere-hours. The positive plates consist of spongy lead, and the negatives "of a specially prepared" substance. Various advantages are claimed, such as absence of buckling, a firm hold on the active material, high conductivity, and a capacity for being transported and stored ready for use in a dry condition.

Continuous Current Transformers.—So far as we are aware, Messrs. Paris and Scott, of Norwich, are the only firm who have hitherto taken up in earnest the question of effecting the transformation of high tension continuous currents into low tension currents. This they have accomplished by the simple device of winding an armature with two circuits, and arranging to run one half as a motor by means of the high tension current, and allowing the other half, working as a dynamo, to generate current at a lower potential. Of course the system can scarcely be expected to lend itself to the distribution of electricity so readily as does the class of transformers in which alternating currents are employed—for the mechanical motion must not only add largely to the cost of the apparatus, but will also tend to prohibit its use for general domestic lighting. At the same time we feel sure that there must be a large number of instances in which such an apparatus will prove of very great value. It has recently been pointed out by M. Cabenallas that the principle is by no means a new one, having been suggested by M. Gramme and described by M. A. Niaudet in the year 1875. The field is therefore thrown open to all comers, so far as the general principle is concerned, although doubtless there will be plenty of room for inventive talent and constructive skill in the development of the most satisfactory arrangement of detail.

The Glasgow Underground Railway.—We are enabled to give the following additional information as to the interesting experiments on train lighting which are now in progress on the underground lines of the North British Railway Company at Glasgow:—The central rail is raised on insulating supports somewhat higher than the rails on each side of it. From underneath each carriage two pulleys or small wheels are suspended, one at each end of the carriage. These pulleys run on the conducting rail, and convey the current from the rail by suitable connecting wires to the incandescent lamps

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within each compartment of the carriage. There is a spring attachment to the pulley, which allows it to rise as far as necessary should the carriage be pressed down a little by a heavy weight of passengers. The pulley has also a horizontal movement, so that between the two motions it may freely run up or down the short slope in which the conducting rail terminates at the mouths of the tunnel. Only one of these pulleys would be required on each carriage, but it is found that the two give a steadier light. The central rail terminates at the end of the tunnel. The wire from the pulley leads to two incandescent Swan lamps, of 16 candle-power each, in the roof of each compartment. Only one of these is used at a time, and in the event of it breaking the second one by a suitable automatic arrangement lights up. The return wire is connected to the wheels of the carriage, and thence the current passes to the ordinary rails, through which the circuit is completed to the dynamo. The great advantage of this system is that there is no connection between the carriages, each carriage taking its own supply of current from the central rail, and that whether the train is standing or in motion. The carriages can thus be shunted in the ordinary way, and there are no connections to be made or broken.

THE JULIEN TRAMCAR IN NEW YORK.—A correspondent of the Philadelphia *Daily News* gives some rather amusing details respecting the introduction of the Julien system on the New York tram lines. According to this statement it appears that an American who happened to see the system in operation at Hamburg introduced himself to the inventor with a view to doing business for him in the States. M. Julien found it extremely difficult to swallow some of the statements which were placed before him, with, perhaps, somewhat injudicious haste by the Yankee, statements which, nevertheless, we have no doubt are perfectly true. Such, for instance, that in Philadelphia alone there are 343 miles of street railways, and that New York and Brooklyn together contain more tramcars than the entire state of Belgium. However, having at length inspired M. Julien with the necessary confidence in his veracity, the Yankee went back to New York and speedily sent an order for a set of batteries and a motor, specifying that they would be required to drive a car to seat thirty persons. We give the rest of the story in the words of the correspondent, from whom we have obtained the above details:—"Mr. (*sic*) Julien accordingly supplied batteries capable of producing power sufficient to carry thirty per.ons. Mr. Bracker sent him a frantic cable-gram, stating that the motor would have to be sufficiently powerful to move seventy passengers. Mr. Julien was serene in his belief that it would have to do nothing of the sort, for the very simple and apparently very conclusive reason that the car could only seat thirty persons. In Belgium and France, you must understand, when every seat in a street vehicle is taken a placard bearing the simple announcement, 'Complet,' is displayed, and while it hangs forth no one attempts to enter the car. It took some time to explain to Mr. Julien that in America railway officials crowd even as many as one hundred persons into a single street car, and if they did not do it they would be roundly abused by the average man, to whom the idea of staying his frantic rush through life by obliging him to 'wait for the next car' would be maddening. So Mr. Julien had to supply the car with new batteries, and it arrived in New York several weeks ago, in readiness to carry seventy passengers. Those passengers have now been carried."

THE ISLE OF MAY LIGHTHOUSE.—A correspondent from Edinburgh kindly sends us the following additional details with regard to the Isle of May lighthouse, which will be read with interest. It will be noted that the optical apparatus enables the spherical illumination of 30,000 candles which is given by the arcs to be concentrated in any one direction, so as to give a beam actually 1,000 times more intense:—"Her Majesty's Commissioners of Northern Lights steam yacht 'Pharos,' left Granton on Saturday, the 18th, having the Commissioners on board, for the purpose of inspecting the new electric light on the Isle of May. The Commissioners present were the Right Hon. the Lord-Advocate, Q.C., C.B., M.P., LL.D., M.S.T.E., the Solicitor-General, Q.C., M.P., the Sheriff of Inverness, who was Commodore for the day, the Sheriff of Aberdeen, the Sheriff of Berwickshire, the Sheriff of Caithness, who is *ex officio* Lord High-Admiral of the Pentland Firth, the Sheriff of Fife, the Sheriff of Forfarshire, Mr. Duncan, advocate, secretary, Mr. Stevenson, engineer, Mr. N. D. Macdonald, Mr. Ivory, and the Rev. Mr. Tait. Some difficulty was experienced in landing on the island as there was a good deal of sea on. After some difficulty the Commissioners were landed and were shown over the buildings. On arriving at the engine house a minute inspection was made of the the engines and dynamos, which were set running. One of the lights was shown by the resident engineer in an adjoining room, the brilliancy of which was blinding. Afterwards the lighthouse and the lantern were inspected. An account of the light appeared in last week's *Electrician*. The resident engineer informed the Commissioners that the light was first started on 1st December, and ran 16 hours without a hitch without having been previously tried. They were also informed that the light had run without a single break every night since then. Also that the experiment had been made of changing from one engine and dynamo to the other, as in the case of accident, and the light was only extinguished for 15 seconds. The electric lamp is changed once an hour to allow it to cool, which change takes three seconds. The light is about 25,000 candle-power, but when seen from the water gives a flash equal to 3,000,000 candles (which can be increased to 6,000,000 candles in a fog), being increased to this amount by the dioptrics. The commissioners returned to Edinburgh at night. At a distance of 50 miles the flash of this light looks as bright as an ordinary oil one does at half a mile."

THE SUBMARINE BOAT "NAUTILUS."—On Monday last we had the pleasure of witnessing some experiments with the submarine boat "Nautilus," at the Tilbury Docks. The "Nautilus" is a cigar-shaped boat, built of steel, 60ft. in length and 8ft. in diameter amidships. She is propelled and steered by electricity. Elwell-Parker cells are employed, and the same firm supplied the switches and other electrical fittings. Two Edison-Hopkinson machines, by Mather and Platt, are used as motors, each machine driving one of a pair of twin screws, which are mounted directly upon the armature shafts, and run at 750 revolutions per minute. The number of cells is 104; they are divided into two separate batteries, one for each motor, and each yields 180 amperes at 100 volts for six hours. The boat is therefore provided with no less than 45 horse-power. The batteries weigh over 10 tons, and the motors very nearly a ton each. At a slow speed the boat can travel at least 75 miles without recharging the cells. The principle upon which the "Nautilus" can be submerged at will is that of displacement. Four large hollow cylinders fitted in stuffing boxes project from the sides, and can be drawn in or pushed out by manual power under the control of the crew. The advantage of this particular arrangement is that the vessel can sink either when running at full speed or when riding at her moorings, and whether motive power is ready or not. On going on board the boat we found the space below deck "cribbed, cabined, and confined" even beyond what we had expected;

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a voyage of fifty miles on board such a craft would be anything but a pleasure trip. However, the "Nautilus" is designed for stern duties, and not for pleasure or comfort. One of the difficulties of submarine navigation is the impossibility of knowing in which direction to steer, except in an open sea (where after her course has been laid on the surface she has only to go straight ahead), and another is the difficulty of stopping or reversing the motion of the boat when once under weigh. These circumstances did not permit any speed trials to be undertaken in the Tilbury Docks. The boat crept about at a slow speed under water, and was steered by the aid of a telephone connected with a skiff which followed her movements. Although the real capabilities of the boat as an offensive weapon were not, therefore, very fully demonstrated, yet we do not entertain any doubt that with the facilities afforded by electric propulsion she is capable of rendering service of the highest value, particularly in the defence of unprotected coast towns. If only some method could be devised whereby she might be steered below water with the same certainty as upon the surface a great advantage would be gained. Possibly some electrician will be able to suggest a means for doing this.

THE LIGHTING OF THE BRIGHTON PAVILION.—At a meeting of the Brighton Town Council on Thursday last, it was stated that, there having been numerous complaints in reference to the present system of lighting the rooms by gas, and the Liverpool and London and Globe Insurance Companies having, in consequence of a report made by Mr. Heaphy, C.E., refused to insure the building if the electric lighting was continued, the committee requested Mr. W. H. Preece, F.R.S., to inspect the pavilion and report. Mr. Preece, after stating that the present wiring was dangerous, said he estimated the cost of putting the present installation into thorough working order at £412. 15s., and secondary batteries would cost another £600. He added that as it was imperative that the existing chandeliers should be used, owing to the peculiarity of the rooms, special wire would have to be obtained, and none but the most experienced workmen should be entrusted with the job. During the three years that had elapsed since the work at the Pavilion, considerable experience had been gained in the proper mode of wiring buildings. In conclusion, he deprecated any proposal to abandon the electric light now that £5,000 odd had been spent upon it, and he pointed out that though the cost of electric lighting was twice that of gas they would have not only its superiority as a light but its greater comfort, its freedom from vitiation of air, its absence of destructive qualities to decorations and fittings, its greater security, and its greater attractiveness to visitors and hirers of the rooms. The committee supplemented this report by stating that Mr. Heaphy had informed them that if Mr. Preece's recommendations were carried out they would fully satisfy the requirements of the insurance companies for which he acted. The committee had also made inquiries as to the cost of improving the arrangements for lighting the pavilion property by gas, regulating the pressure, improving the lighting, and economising the consumption of gas, and they had received from Mr. Sugg an approximate estimate amounting to £1,500, of which about £1,000 would be for the Royal Pavilion proper. They recommended that the use of the electric light in the pavilion and dome, the picture galleries, library, and museum should be resumed; that secondary batteries should be employed sufficient for 10 hours lighting of the banqueting room, corridor, saloon, and one drawing room. To accomplish this, 106 cells would be required at an estimated cost (including fixing) of £660; that the relaying of the wires in grooved boarding, and the other recommendations in Mr. Preece's report should be carried out; that the services of an electrician at £2 per week should be secured, and that he should commence his duties concurrently with the carrying out of the suggested additions and alterations.

A DISTINCTION *with* A DIFFERENCE.—We were recently somewhat surprised to learn that in certain quarters which might have been supposed to be tolerably well posted up in such matters there exists a decided misconception as to the precise difference between the accepted significations of such everyday terms as "electromotive force" and "difference of potential." We have always understood that electromotive force may be defined as *that which causes* a difference of potential; and this definition is not by any means a mere scholasticism, for the simple reason that in a closed circuit containing a single source of electromotive force, the latter has (or may have) only one fixed value, while the value of the "difference of potential" depends upon the position in the circuit of the points between which this difference is measured, and may therefore have any number of different values from zero up to that of the E.M.F. itself; while at the same time all values of potential difference are caused by, and are proportional to, the E.M.F. Hence in a dynamo we speak of the "difference of potential at the terminals," or at the lamps, which is caused by "the internal electromotive force." That an attempt should at this date be made to upset an established convention of so useful and convenient a character is, we think, decidedly to be deprecated. The following paragraph, which appears in a contemporary journal, has induced us to enter this protest:—"A correspondent of the *English Mechanic* quotes a passage from the *Electrical Review* as follows:—'When the external resistance approaches the internal resistance, the E.M.F. of the cells will be reduced, and if the external was made equal to the internal resistance the E.M.F. would be but half that indicated when the external resistance was high. How is this? I thought that the E.M.F. of any cell depended solely upon the materials composing the two plates, and the composition of the battery acid representing electro-chemical actions of various kinds, each of which produced its own particular E.M.F.'" On this the journal referred to subjoins, "The above statement is correct. The querist confuses the full potential, or E.M.F. on open circuit, with the free potential when the battery is working. If he will measure the E.M.F. of a cell which is not connected up with any exterior circuit, he gets the full potential between its terminals, but if he joins the terminals up to a resistance equal to the internal resistance of the cell, he will find that only half the potential is free. If he proceeds still further, and short circuits the cell with a thick piece of copper wire, he will find the free potential between the terminals reduced to practically zero." For ourselves, we beg leave to assert that, in accordance with the views which we had thought to be universally accepted, the correspondent of the *English Mechanic* is perfectly correct in his assumption that the E.M.F. of the cell is a constant quantity, subject, however, to the influence of such secondary chemical re-actions as may take place in the cell, and also to a certain slight extent depending upon temperature, but otherwise quite independent of the resistance of the circuit, both external and internal. The "difference of potential" at the terminals of the cell is, upon the other hand, a function of the E.M.F. and of the external and internal resistance, and there is nothing in the correspondent's query to show that he was not perfectly well acquainted with these elementary facts. We trust that it is not proposed to speak in future of the "free potential" of a dynamo machine.

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 121.)

We have seen that a wire conveying a current exerts a force upon a magnetic pole in its neighbourhood. The magnitude of this force depends upon the strength of the magnetic pole, being proportional to it, the strength of the current, being proportional to it also, the length and shape of the wire, and the position of the pole relative to the several parts of the wire. Upon this action the electromagnetic system of units is based.

In this system the unit of current is first defined, as follows:

The electromagnetic unit of current is that current which, flowing in a wire one centimetre long, every point of which is in the same plane, and distant one centimetre from a unit magnetic pole, which is also in the same plane, exerts through air upon the unit pole a force of one dyne.

From this it appears that the wire must form an arc of a circle of one centimetre radius, and having the unit pole at its centre. The force exerted upon the pole will, of course, be perpendicular to the plane of the wire.

In all electromagnetic measurements, instead of employing a single centimetre of wire, a coil containing several turns of wire is used, the length of wire and the position of every turn being accurately determined. The wires which bring the current to and from the coil may then enter and leave the coil at nearly the same point, and if they are insulated and twisted round one another, their effect upon a magnet at the centre of the coil will be negligible.

If a single circle of wire of one centimetre radius conveyed a unit current. a force of 2π dynes would be exerted on a unit magnetic pole at the centre of the coil. If the size of the circle be varied, the force exerted on a unit pole at its centre will vary inversely as its diameter.

The absolute unit of electromotive force is that electromotive force which does unit work (one erg) in unit time (one second), when urging a unit current through a conductor.

Or we may define the unit of electricity as that quantity which passes in one second across a section of a conductor, conveying the unit current, and thus define the unit electromotive force as that which does unit work on the unit of electricity, so that it corresponds to unit difference of potential.

The absolute unit of resistance is the resistance of a conductor in which a unit electromotive force produces a unit current.

Hence, in a conductor of unit resistance, a unit electromotive force produces unit current, and does a unit of work (one erg) in a unit of time (one second).

The absolute units above defined are not those adopted in practice, the absolute units of electromotive force and of resistance being far too small for convenience, while the absolute unit of current is somewhat large.

The ampere, the unit of current adopted in practice, is one-tenth of the absolute unit. The absolute unit is therefore equal to ten amperes, which is about the current employed for arc lamps of 1,000 candle-power. Such a lamp consumes about two-thirds of a horse-power. For a horse-power is equal to 7,458,000,000 ergs per second, and an arc lamp taking ten amperes consumes 5,000,000,000 ergs per second. Hence, the electromotive force required to light such an arc lamp is 5,000,000,000 absolute units. The volt, which is the unit adopted in practice, is equal to 100,000,000 or 10^8 absolute units, and therefore the E.M.F. required to light the arc lamp is 50 volts.

The unit of resistance, or the ohm, is the resistance of a conductor in which the unit of electromotive force, or volt, can produce the unit of current, or ampere—that is, the resistance of a conductor in which 10^8 absolute units of electromotive force can produce $\frac{1}{10}$th of an absolute unit of current, and this resistance is clearly 10^9 or 1,000,000,000 absolute units of resistance.

Since the work done by an electromotive force E in sending a current C is E C ergs per second, if all the quantities are in absolute units, it follows that an electromotive force of one volt sending a current of one ampere will do $10^8 . \frac{1}{10} = 10^7$ ergs per second. This rate of doing work is called a *watt.*

Again, the work done by a current C in flowing through a resistance R is C^2R ergs per second, if all the quantities are expressed in absolute units. Hence, one ampere flowing through an ohm will do $(\frac{1}{10})^2 10^9 = 10^7$ ergs per second, which is the same as that done by a volt in urging an ampere, as of course it should be.

A watt	$= 10^7$ ergs per second.
An ohm	$= 10^9$ absolute units.
A volt	$= 10^8$ absolute units.
An ampere	$= 10^{-1}$ absolute units $=$ volt $\div$ ohm.
A horse-power	$= 745{\cdot}8$ watts.

The horse-power consumed in sending any current may be obtained by multiplying the E.M.F. expressed in volts by the current expressed in amperes, and dividing the product by 745·8 (or for practical purposes by 746). If all the energy is consumed in overcoming resistance, the horse-power may be determined by multiplying the square of the current expressed in amperes by the resistance expressed in ohms, and dividing the product by the same number as before.

If an incandescent lamp is ignited by an E M.F. of 60 volts, sending a current of 1·2 amperes, the rate of doing work will be 72 watts or 720,000,000 ergs per second. A foot pound is equal to about 13,560,000 ergs. Hence the work done in lighting the lamp will be equal to $\frac{7200}{1356}$ foot pounds per second, or about 191,150 foot pounds per hour. The amount of work which, if entirely converted into heat, would raise 1lb. of water 1°C., is 1,390 foot pounds. Hence, the heat developed in the incandescent lamp in one hour would raise nearly 1·38lbs. of water from the freezing to the boiling point. The heat developed by the combustion of five cubic feet of coal gas would raise nearly 18lb. of water through the same range of temperature.

The absolute unit of quantity is the quantity of electricity which is conveyed in one second by the unit current.

The absolute unit of capacity is that of a condenser which can be charged with the unit of quantity by the unit of electromotive force.

A farad is the capacity of a condenser which, when charged to the potential of a volt, contains an amount of electricity equal to that which is conveyed in one second by a current of one ampere.

A farad is therefore equal to 10^{-9} absolute units of capacity. A microfarad is the millionth of a farad, and is equal to 10^{-15} absolute units of capacity.

Since action and reaction are equal and opposite, it follows that the pole of a magnet will exert a force upon a wire conveying a current equal and opposite to that which the wire exerts upon the pole. Hence, a unit magnetic pole placed at the centre of a circle of wire of one centimetre radius in which a unit current is flowing, will exert a force of one dyne on every centimetre of the wire. But a unit magnetic pole exerts a force of one dyne upon another unit pole at a distance of one centimetre—that is, produces a magnetic field of unit strength at a distance of one centimetre. Hence, replacing a magnetic pole by the field which it produces, we see that a centimetre of wire conveying a current, and placed in a unit magnetic field, so as to be at right angles to the lines of magnetic force, will be acted upon by a force of one dyne, urging the wire at right angles to its own direction, and at right angles to the magnetic lines of force. Thus, if the lines of force pass from north to south, and the current flow from east to west, the mechanical force upon the wire will act vertically upwards. If the lines of force pass vertically downwards, and the current flow from west to east, the mechanical force on the wire will urge it from south to north.

Suppose there are two straight metal bars running parallel to one another from south to north. Let a third bar be capable of sliding in contact with each of these bars, and let a current enter the south end of the bar which lies west of the other, pass through the cross bar, and return to the battery from the south end of the eastern bar. Suppose that the whole system is in a uniform magnetic field and that the lines of force pass vertically downwards. Let the strength of the field be H, the strength of the current C, and let the length of the sliding bar, *i.e.*, the distance between the parallel bars, be *l*, all these quantities

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being expressed in absolute units. Then there will be H lines of force passing through every centimetre of the horizontal plane which contains the conductors. The cross wire will be urged at right angles to itself and to the lines of magnetic force, and will tend to slide from south to north. Since unit force acts on each centimetre of a wire conveying unit current in a unit magnetic field, the force upon this wire will be HCl dynes, since its length is l centimetres, the current conveyed is C units, and the strength of the field H. If the wire move in obedience to this force work will be done by the electromagnetic forces, and the requisite energy must be derived from the battery urging the current, since there is no other source of energy in the system which can be drawn upon. If the current remain the same as when the wire is at rest, the whole of the work done by the battery will be converted into heat; but if the current be diminished, the work done by the battery will be diminished in proportion, but the heat generated will be diminished at a faster rate, being proportional to the square of the current, and then, and only then, will the work done by the battery exceed the heat generated and be able to furnish the energy required to do the necessary mechanical work on the wire. Suppose that E is the E.M.F. of the battery, R the resistance of the circuit which we suppose constant, then $E = CR$ if C be the current flowing when the crossbar is stationary. Let C' denote the current when the bar is moving with a velocity of v centimetres per second. Then the resultant electromotive force in the circuit must be $C'R$, and there must therefore be an electromotive force, e, introduced by the motion, which electromotive force opposes the battery and is equal to $(C - C')R$. The magnitude of this opposing E.M.F. may be thus determined :—

The mechanical force acting on the cross conductor is $HC'l$. Hence the mechanical work done in a second is $HC'lv$ ergs. But the work done by the battery is EC' ergs, or CRC' ergs, since $E = CR$, and the energy converted into heat is C'^2R ergs. Hence the work done by the battery in excess of the heat generated is $C'CR - C'^2R$ or $(C - C')C'R$ ergs. Therefore by the conservation of energy,

$$(C - C')C'R = HC'lv,$$

or,

$$(C - C')R = Hlv,$$

that is, the electromotive force opposing the battery which is introduced by the motion of the conductor is equal to Hlv, which is the number of magnetic lines of force cut across in a second by the conductor of length l moving with velocity v through a magnetic field in which there are H lines of force per square centimetre.

(*To be continued.*)

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXIV.

BY OLIVER HEAVISIDE.

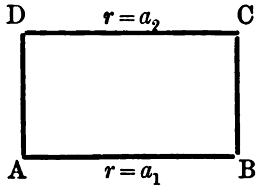
(*Continued from page 11.*)

Extension of the Preceding to Include the Propagation of Current into a Wire from its Boundary.

The first step to getting out of the wire into the dielectric occurs in Sir W. Thomson's theory, Section XXXII. We certainly get as far as the boundary of the wire. To some extent we make progress in adopting (same section) Maxwell's idea of the continuity of the conduction and the dielectric current, when the conduction current is discontinuous itself. Further progress is made (Section XXXIII.) in introducing the electric force of inertia and the magnetic energy, so far as dependent on the first differential coefficient of the current with respect to the time, assuming the magnetic field to be fixed by the single quantity C, the wire current, just as the electric field is fixed by the single quantity V, the potential difference of the two wires at a given distance.

But the magnetic machinery does not move in rigid connection with the wire current, as is implied in the specifications of the magnetic energy by $\frac{1}{2}LC^2$, like that of the electric energy by $\frac{1}{2}SV^2$, L and S being the inductance and the electrostatic capacity, per unit length of line. In going further, I believe the following to be the most elementary method possible, as well as being pretty comprehensive. To fix ideas, and simplify the nature of the magnetic field, let the line consist of two concentric tubes, separated by a dielectric non-conducting tube. The dielectric is to occupy our attention mainly in the first place. Let a_1 and a_2 be its inner and outer radii, a_0 the inner radius of the inner tube, and a_3 the outer radius of the outer. Find the connection between the longitudinal electric force at the inner and outer boundaries of the dielectric tube, and the E.M.F. of the condenser, and the E.M.F. of inertia, so far as it depends upon the magnetic field in the dielectric.

Let ABCD in the figure be a rectangle in a plane through the common axis of the tubes, AB being on the inner and CD on the outer boundary of the dielectric, both of unit length. Let the current be from A to B in the inner tube, in which direction x is measured, and therefore from C to D in the outer tube. These currents are not precisely equal under all circumstances, but are so nearly equal that we can ignore the longitudinal current in the dielectric in comparison with them; thus the current C in the inner necessitates the same current C in the outer tube. The lines of magnetic force are directed upward through the paper, and the intensity of force is $2C/r$ at distance r from the common axis of the tubes.



The total induction through the rectangle is therefore

$$\mu_2\int_{a_1}^{a_2}\frac{2C}{r}dr = \left(2\mu_2\log\frac{a_2}{a_1}\right)C = L_0C,$$

if μ_2 be the inductivity of the dielectric, and L_0 the inductance of the dielectric per unit length of line.

Now, the rate of decrease of the induction with the time, or $-L_0\dot{C}$, is the E.M.F. of inertia in the circuit ABCD in the order of the letters. But if E and F are the longitudinal electric forces in AB and DC, and V and W the radial forces in BC and AD, another expression for the E.M.F. in the circuit is $E - F + V - W$. But as AB and CD are of unit length, $V - W = dV/dx$. Hence

$$E - F + \frac{dV}{dx} = -L_0\dot{C}, \quad \text{or} \quad -\frac{dV}{dx} = L_0\dot{C} + E - F \quad (73b)$$

Next, let Γ_1 and Γ_2 be the longitudinal current densities at the boundaries of the conductors, ρ_1 and ρ_2 their resistivities, and e_1, e_2 the impressed forces, if any, in them. Then, by Ohm's law,

$$e_1 + E = \rho_1\Gamma_1, \qquad e_2 + F = \rho_2\Gamma_2;$$

and therefore

$$E - F = \rho_1\Gamma_1 - \rho_2\Gamma_2 - e, \quad . \quad . \quad . \quad (74b)$$

if $e = e_1 - e_2$. Thus e is the impressed force in the circuit per unit length, irrespective of how it is divided between the inner and the outer conductor. Also, e is supposed to be longitudinal.

Now use (74*b*) in (73*b*), making it become

$$e - \frac{dV}{dx} = L_0\dot{C} + \rho_1\Gamma_1 - \rho_2\Gamma_2. \quad . \quad . \quad (75b)$$

We now require to connect Γ_1 and Γ_2 the current densities at the boundaries of the conductors, with the total currents in them; representing these connections thus,

$$\rho_1\Gamma_1 = R_1''C, \qquad -\rho_2\Gamma_2 = R_2''C, \quad . \quad . \quad (76b)$$

we require to find the forms of R_1'' and R_2'', one for the inner, the other for the outer conductor. If this be imagined to be done, and we put

$$R'' = L_0(d/dt) + R_1'' + R_2'',$$

the equation (75*b*) becomes

$$e - \frac{dV}{dx} = R''C = L_0\dot{C} + R_1''C + R_2''C \quad . \quad . \quad (77b)$$

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wherein R″ is known. The complete scheme will therefore, be,

$$e-\frac{dV}{dx}=R''C, \quad q=SV, \quad -\frac{dC}{dx}=\frac{dq}{dt}=S\dot{V} \quad (78b)$$

which should be compared with (71*b*) and (72*b*). As for the equations of V and of C, they may be obtained by elimination, but it is unnecessary to write them at present.

We have supposed R_1'' and R_2'' to be known. The question is, then, how to find them. We know that in steady flow they must be R_1 and R_2, the steady flow resistances of the conductors. We know, further, that they are $R_1+L_1(d/dt)$ and $R_2+L_2(d/dt)$, when only the first derivative $\dot{C}$ of the current is allowed for. Now, we know that, under all ordinary circumstances, the length of a wire must be a very large multiple of its diameter before the influence of the electrostatic charge becomes sensible. When it does become sensible the current is of a different strength in different parts of the line during the setting up of a steady current. But in a section of the line which, though long compared with the diameter of the wire is short compared with its length, the current changes insensibly, even when the change is very great between the current strength in that section and in another, which, by contrast, may be called distant from the first.

It is clear, therefore, that we shall come exceedingly near the truth if, in the investigation of the function R_1'' we altogether disregard the change in strength of the current in passing along the line. This amounts to ignoring the small radial component of the current in the conductors, and making the current quite longitudinal. This is only done for purposes of simplification, and does not involve any physical assumption in contradiction of the continuity of the current; for we join on the dielectric current to that in the conductors, by means of the equation of continuity, the third of (78*b*).

The determination of R_1'' and R_2'' is thus made an electromagnetic problem, of which I have already given the solution. See equation (50*b*), Section XXX (August 6th, 1886), where, the first big fraction represents R_1'' for the inner conductor and the second R_2'' for the outer. The separation of these into even and odd differential coefficients, thus

$$R_1''=R_1'+L_1'p,$$

is of principal utility in the periodic applications. It may be perhaps as well pointed out that in the first equation (78*b*), we should, in strictness, clear off fractions to obtain the rational differential equation. But the advantages of the form (78*b*) are too great to be lightly sacrificed to formal accuracy.

We have now the means of fully investigating the transmission of disturbances along the line, including the retardation to inward transmission from the dielectric into the conductors as well as the effects of the electrostatic charge. The system is a practical working one; for, the electrical variables being V and C, we are enabled to submit the line to any terminal conditions arising from the attachment of apparatus, the effect of which is fully determinable, because the differential equation of the apparatus itself is one between V and C. Both the ratio of V to C and their product are important quantities. The first is, in steady flow, a mere resistance. In variable states it becomes a complex operator of great importance in the theoretical treatment. The second is the energy current, concerning which more in the next section.

In the meantime I will briefly indicate the nature of the changes made when we go further towards a complete representation of Maxwell's electric and magnetic connections. First, as regards the small radial component of current in the conductors. The quantity s that appears in the expression for R_1'' is given by

$$-s_1^2=4\pi\mu_1k_1p,$$

μ_1 being the inductivity and k_1 the conductivity of the inner conductor, whilst p is, when we are dealing with a normal system of subsidence, a constant; thus, ϵ^{pt} is the time factor showing how it subsides, p being always negative in an electro-magnetic problem, and also always negative in an electrostatic problem, whilst in a combined electrostatic and electro-magnetic case it is either negative and real, or negative with an imaginary part, when its term must be paired with a companion to make a real oscillatorily subsiding system. Now the simplest form of terminal condition possible is $V=0$ at both ends of the line, *i.e.*, short circuits. Then

$$V=A\sin(j\pi x/l),$$

where j is any integer, represents a V system, satisfying the condition of vanishing at both ends. Let the factor of x, which is $j\pi/l$, be denoted by m. Only the first few j's are of much importance, 1, 2, 3, &c. Now, if we change the connection between s_1 and p above given to

$$s_1^2=-4\pi\mu_1k_1p+m_1^2,$$

we shall be able to take the radial component of current in the conductors into account; but the change made is usually very insignificant. There are four other cases in which we can work similarly—viz., when the line is insulated at both ends, or $C=0$; when it is insulated at either end and short circuited at the other—two cases; and when the line is closed upon itself, each conductor making a closed circuit without interposed resistances, &c. In all except the last case, when the line has no ends, the quantity VC vanishes at both ends of the line, either V or C being zero at these places, so that no energy can enter or leave the line (dielectric and two conductors). Nor can this happen in the last case. But if we join on terminal apparatus, thus making VC finite at one or both ends, the system breaks down, and we require to fall back upon the preceding.

But if we keep to the five cases mentioned, we may make a further refinement, by taking the longitudinal current in the dielectric into account, which we have previously considered negligible in comparison with the current C. We cannot do this in terms of V, which is inadequate to express the electric energy. But we may do it in terms of the electric and magnetic forces, and then obtain a full representation of Maxwell's connections, instead of an approximate. But even in this it is assumed that there is no magnetic disturbance outside the outer conducting tube or inside the inner, which there must really be, for we must have continuity of the tangential electric force, which necessitates electric force, and therefore also electric displacement and current and magnetic force, outside the outer tube, having some minute disturbing effect on the current in the conductors.

We may, however, leave these refinements to take care of themselves, and return to the V and C system of representation. The advantage of dealing with concentric tubes is due to the circularity of the lines of magnetic force, which produces considerable mathematical simplifications, as well as physical. Suppose, however, the tubes are not concentric, although the dielectric is still shut in by them. Here, clearly, to a first approximation we have merely to give changed values to the constants S and L, whilst R is unchanged. But to go further, the determination of R_1'' and R_2'' will present great difficulties. This, however, is clear: that the full L′ will have for its minimum value, approached with very rapid oscillations, L_0, such that $SL_0=v^{-2}$, where v is the speed of propagation of undissipated disturbances through the dielectric. This follows by regarding the conductors as infinitely conducting, so that there is no waste in them, when the equation of V becomes

$$\frac{d^2V}{dx^2}=\mu_2c\frac{d^2V}{dt^2}, \quad \text{or}=SL_0\frac{d^2V}{dt^2}, \quad . \quad (79b)$$

showing wave propagation with velocity v.

But if the two conductors be parallel solid wires or tubes (not concentric), and be placed at a sufficient distance from one another, the lines of magnetic force in and close round the conductors will be very nearly circles, so that we may regard R_1'' and R_2'' as known by the preceding; and we can therefore go beyond the approximate method of representation founded upon R, S, and L only. Even if we bring the conductors so close that there is considerable disturbance from the assumed state, we should still, in reckoning R_1'' and R_2'' in the same way, go a long distance in the direction required, especially in the case of iron wires, in which, by reason of the high inductivity, the magnetic retardation is so great.

The effect of leakage has not been allowed for in the preceding. The making of the necessary changes is, however,

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quite an elementary matter in comparison with those connected with magnetic retardation. We require to change the form of the equation of continuity. If there be a leakage fault on an otherwise perfectly insulated line, we have the line divided into two sections, in each of which the former equations hold good; whilst at the place of the leak there is continuity of V and discontinuity of C, the current arriving at the leak on the one side exceeding that leaving it on the other by the current in the leak itself, which is the quotient of V by the resistance of the leak, if it be representable as a resistance merely. But when the leakage is widely distributed it must be allowed for in the line equations. Even in the case of leakage over the surface of the insulators of a suspended wire, the proper and rational course is to substitute continuously distributed leakage for the large number of separate leaks; which amounts to the same thing as substituting a continuous curve for a large number of short straight lines joined together so as to closely resemble the curve. The equation of continuity becomes

$$-\frac{dC}{dx} = KV + S\dot{V} \quad . \quad . \quad . \quad . \quad . \quad (80b)$$

where the fresh quantity K is the conductance, or reciprocal of the insulation resistance, per unit length of line. That is, the true current leaving the line is the sum of the former $S\dot{V}$, the condenser current, and of KV the leakage current, both of which co-operate to make the current in the line vary along its length, although in the steady state it is the leakage alone that thus operates. But as regards retardation, their effects are opposed. The setting up of the permanent state is greatly facilitated by leakage, as is most easily seen by considering the converse, viz., the subsidence of the previously set up steady state to zero when the impressed force is removed. If, then, we wish to increase the clearness of definition of current changes at the distant end of a line on which electrostatic retardation is important, we can do it by lowering the insulation resistance as far as is practicable.

(To be continued.)

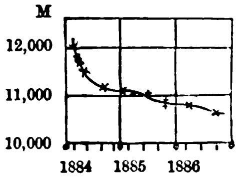
PERMANENT MAGNETS.—III. ON MAGNETIC DECAY.*

BY R. H. M. BOSANQUET, St. John's College, Oxford.

In the *Philosophical Magazine*, ser. 5, XIX. 1885, pp. 57-59, I gave an account of the decay of the magnetism of a pair of permanent magnets during some months after they were made.

Observations for H have been continued at intervals with the same pair of magnets, both in the laboratory and the non-magnetic room; incidentally a large number of determinations of the moments of these magnets have been obtained, and from these an interesting result appears to follow with considerable certainty.

The decay of the magnetism proceeds much more rapidly in summer than in winter; and in all probability the rate of decay is quicker for higher temperatures and slower for lower temperatures.



It will be remembered that Joule proved, by burying systems of magnets for several years, that the maintenance of a constant temperature did not secure the constancy of the magnetic intensity (Reprint, Vol. I., page 592), on which Joule remarks, "so that the cause of the gradual decline of power has yet to be discovered."

Regarding heat as a species of molecular agitation, it seems reasonable to expect that this agitation should act in a manner analogous to mechanical disturbances, in facilitating the decay of permanent magnetism. In fact, we know that by exposing permanent magnets to moderately high temperatures, we can destroy their magnetism altogether.

The following are the mean results of the sets of observations that have been made. The changes in the value of M are shown in the figure. It will be seen that they are much greater in summer than in winter.

N.B.—The temperatures were always noted, and the temperature-coefficients of the magnets were determined by a careful discussion. They are not large enough to produce any difference in the numbers which need be taken into account for the present purpose.

NONMAGNETIC ROOM.

Mean date.	No. of sets.	Temp. F.	M.	H.
1884.				
February 18	9	......	12,039	·18044
March 3	6	......	11,822	·18075
September 18	16	......	11,119	·18020
1885.				
January 4	11	41°·8	11,092	·18100
May 28	17	61·4	11,034	·18212
October 24	10	53·5	10,876	·18101
1886.				
April 19	10	50·7	10,826	·18025
September 24	22	60·4	10,656	·18078

LABORATORY.

Mean date.	No. of sets.	Temp. F.	M.	H.
1884.				
March 15	12	......	11,767	·17261
April 8	11	......	11,620	·17224
September 18	14	......	11,121	·17370
1885.				
January 2	16	42°·7	11,095	·17333
May 6	26	52·6	11,002	·17456
October 24	9	60·1	10,819	·17446
1886.				
April 15	21	47·5	10,805	·17424
September 24	30	58·0	10,661	·17426

* From the *Phil. Mag.* for December.

SECONDARY BATTERY PATENTS IN THE UNITED STATES.

Owing apparently to the recent introduction of the Julien battery for tram-car work upon the New York lines, the Brush Electric Company has issued the following notice:—"On May 17th, 1882, the public was cautioned against making investments in any scheme or venture based upon the claims of one Camille Alphonse Faure, relating to secondary or storage batteries or accumulators, and notice was then given that the Brush Electric Company, of Cleveland, were the rightful owners in this country of the inventions laid claim to by Faure and others, and were enforcing their rights by proceedings before the proper tribunals of this Government. Those proceedings have been pushed with diligence by the Brush people, and have been opposed and delayed in every possibl· way by the Faure interests and others for a period of four years. Decisions, however, have at last been rendered in favour of the Brush interest, and patents have been granted to it covering the entire ground claimed by the Faure people, and the Faure patent is thus rendered valueless. Twenty-seven patents, covering the field above referred to and of cognate scope, have been granted to the Brush Electric Company, and one or more of them cover all the commercial batteries that have been up to now devised. The two principal and foundation patents, which control the use of the so-called Faure storage battery, as well as the Sellon-Volckmar battery and others in this country, and supersede the patent issued to Faure, Jan. 3, 1882, numbered 252,002, are dated and numbered respectively March 2, 1886, No. 337,298, and March 2, 1886, No. 337,299. The public are again advised, as they were in 1882, of the rights of the Brush Electric Company, and that these rights will be enforced."

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in The Electrician, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes 137
Elementary Electricity and Magnetism—II. (Continued.) 142
Electromagnetic Induction and its Propagation. By Oliver Heaviside. (Continued.) ... 143
Permanent Magnets.—III. On Magnetic Decay. By R. H. M. Bosanquet. Illustrated 145
Secondary Battery Patents in the United States............... 145
The Hire and Purchase System 146
Correspondence...................... 147
Investigations on the Action of Solenoids on Differently Formed Iron Cores. Illus... 147
Electric Street Cars 150
Electric Bells. Illustrated...... 152
Glow Lamps, their Use and Manufacture. By Major-Gen. C. E. Webber, R.E, C.B. (Concluded.) Illustrated ... 152
Some Experiments on Secondary Cells. By J. Swinburne. 153
Legal Intelligence 154
Companies' Meetings—
The Gülcher Electric Light and Power Company 156
The New Telephone Company.. 158
New Company 158
Companies' Share List............ 158
Telegraph Traffic Receipts for November 158

THE HIRE AND PURCHASE SYSTEM.

With the steady growth in the manufacture of dynamos, and an ever increasing demand for them, there has arisen a difficulty which older industries of a similar kind have wholly or partially overcome, but which is quite novel to the Electrical Engineer. We refer to the high price of his goods. Possibly the cost of material and construction may be somewhat reduced as time goes on; but not, we think, to any considerable extent. The highest scientific authorities, so far, do not favour cheap machines, and the circumstances of the last three or four years have certainly not conduced to set a higher price on the dynamo than its makers are justly entitled to. On the contrary, it is known that they have sometimes made and sold at a loss. Probably, therefore, the present prices of firms who have a good reputation will be maintained. This being so, they are confronted with precisely the same question with which agricultural implement makers and the makers of steam engines had to deal in the early days of their career, namely, how to find a market for their commodities where ready capital was not available for a large immediate expenditure.

To put the matter plainly, we will suppose that electrical plant is wanted for electric lighting or mechanical purposes by a man of good credit, or a perfectly respectable firm who may not be willing, or possibly not be able, to purchase outright with cash down. At present there is no recognised usage in the electrical engineering trade to justify any course other than sale for cash or credit—the latter method being always attended with risk. In reality, if the plant cannot be paid for it cannot be had. But this is not the case in respect to some other well-known businesses. Notably, there is the familiar hire system applicable to furniture, and, we believe, recognised by law. A similar plan, if we are not mistaken, has been for some time in vogue among the makers of steam engines, which are let out for hire on the redemption purchase system. Individuals or firms situated as above described are enabled under such provisions to obtain and employ machinery which is partly paid for, but which remains the property of the maker until the whole price is cleared off, or reverts to him on payments failing. No custom of this kind has yet been tried in the electrical engineering trade, not, at all events, to an extent which would stamp it as a usage of the trade in any court of law.

To establish this usage, in the legal sense of the word, would, we think, be of considerable service to the firms now engaged in manufacturing dynamos and other expensive electrical appliances; for without some such recognised usage there is reason to fear that property once out of the hands of the makers would be liable to seizure under an act of bankruptcy, the far-reaching and sweeping powers of which are of a most comprehensive and indiscriminate character. Nobody seems to know what trustees in bankruptcy may not seize, but as the prevailing belief is that they will seize anything, and can be made to restore only with extreme difficulty, nobody cares to run any great risk in order to challenge these powers. It is even thought that the stringent agreement customary in the case of old established hire systems would not avail where custom has not sanctioned it, the argument being that creditors are not sufficiently warned that property on the premises may be only there on hire, in cases where, unlike that of furniture for example, the custom of hiring is not common and generally known.

Now the seizure of hired property under the bankruptcy of the hirer would be very hard upon the owner, even if he had received part of the purchase instalments; but it would be vastly worse if he had only let the property on hire with or without the option of purchase. Yet to both of these contingencies the owner of electrical plant would be liable. More correctly, we should say he believes he is liable; and the belief is undoubtedly acting as a deterrent against parting with his goods without money down; and consequently preventing him doing business where otherwise he might be doing it. This is not only bad for the electrical engineer, but bad for the progress of electric lighting and electrical machiney everywhere. It is not desirable to push a business otherwise flagging by illigitimate means; but where the demand is largely increasing, and the supply only flags because of a legal technicality, any efforts to remove it out of the way are perfectly legitimate and highly desirable.

To this end we would venture to offer a few practical suggestions, the first of which is to invite correspondence on the points we have raised, namely, as to the expediency of adopting some form of the hire system, or hire-and-purchase system, to the business of electric engineering; and as to liabilities supposed to be incurred by adopting either of those systems. Some experience may have already been gained that has not come to our knowledge, and some legal opinion may have been obtained which, if made public, would be exceedingly useful. Secondly, we suggest correspondence on the question whether it would be practicable for members of the trade to combine for the purpose of making their willingness to let out machinery on hire known to the public with the view of establishing the "usage" which is wanting in this particular "trade;" and, further, whether such

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a combination acting in the way suggested would have any legal effect in securing property against seizure in the event of the purchaser or hirer becoming bankrupt. Of course every contractor acting on his own responsibility will take care that his name plates and labels are affixed to his plant; and where there is risk he will retain practical possession by leaving his own *employés* in charge of it. Other precautions for immediate use will readily suggest themselves; but we think, on the whole, that the safest course will be for persons interested to act together in this matter for some time to come; and with this end in view we shall freely open our correspondence columns to any useful hints or suggestions that may reach us. The subject is not exactly a cheerful one, but in a sense it is seasonable. Christmas is the time for overhauling accounts as well as paying them, and the outlook for the coming year may be rendered more hopeful by due consideration of the subject we have here started. But be this as it may, our readers, one and all, may be assured of our hearty goodwill and best wishes for the season, and for the coming New Year.

CORRESPONDENCE.

BABBAGE'S NOTATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly grant me space to ask whether any of your readers can inform me of a publication containing the system of Notation invented by Babbage. This system was, I believe, first explained in a paper read by the author before the Royal Society in 1826. As none of the public libraries in this neighbourhood have the *Proceedings* of the Society for that date, I am unable to get what I want.

The Notation is referred to in a great number of books, but so far as I am able to ascertain not the slightest explanation of the method is contained in any of Mr. Babbage's numerous works now in circulation. Perhaps some of your mathematical readers will be able to guide me.—Yours, &c.,

12, Langside-road, Govanhill, Glasgow. DAVID COOK.

INVESTIGATIONS ON THE ACTION OF SOLENOIDS ON DIFFERENTLY FORMED IRON CORES.*

There have been numerous experiments made on the mutual action between solenoids and iron cores. Of the earlier ones the most remarkable are those of Hankel. Lately we have had those of Krizik and Böttcher, in which trials have for the first time been made also with doubly conical cores. The significance of these last investigations lies especially in the fact that they are the first which have been made on the attraction between non-cylindrical iron cores and a solenoid. The results of Böttcher and Krizik, however, disagree, and it becomes of some importance to make accurate investigations on the attractions between solenoids and iron cores of other than cylindrical shape.

The most usual regulators of arc lamps can be divided into two classes: the first and greater one, where a solenoid and iron core remain essentially always in the same position relative to one another; and a second one where the iron core continually shifts its position relatively to the fixed solenoid as the carbon burns away.

In this last arrangement it appears to be desirable that the force between the solenoid and iron core should remain constant, or nearly so—a thing which is impossible in the case of a cylindrical core. It has been proposed to compensate the variation of the attraction in this case by a mechanical arrangement; but this would detract from simplicity and compactness, both special requisites for the regulator of an arc lamp. Efforts have been made on the other hand to make the action between the solenoid and its core uniform in itself, without further mechanism; and such efforts were, it seems, first made by Krizik.

Krizik made experiments both with cylindrical and doubly conical cores, and among his results were the following:—In the case of a cylinder he supposed that the maximum attraction took place when the end of the cylinder was at the middle of the length of the solenoid, and that from thence the attraction diminished to zero, and then to a negative maximum.

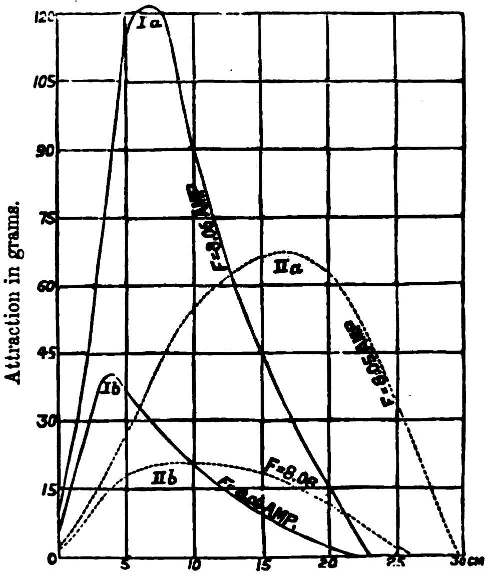
He supposed that two cones united at their bases might give uniform action within certain limits.

Böttcher declared that Krizik's results were wrong, and said that the maximum attraction did not take place when the end of the core coincided with the middle of the length of the coil, and that the action with the double cone did not differ essentially from that with a cylinder. Other investigators also have not confirmed Krizik's results.

The author then proceeds to describe his own investigations on the subject.

He first tried whether the relative lengths of the coil and the cylinder had any influence. He shortened his first-used coil to a half, then to a quarter, of its original length, and finally used one winding only; but in each case the attraction was unaffected by the relative lengths of the coil and core.

The results of the next part of his researches, which relate to the variation of attraction with relative position, are given by the curves of the diagram, in which abscissæ represent the distances of the lower end of the core under the upper end of the solenoid, whilst the ordinates represent the corresponding attraction in grams. The iron cylinder employed was 39cm. long, whilst the coil had the lengths 0·8, 3·5, and 7·0cm. Only the results for the latter two lengths of the solenoid are given in the diagram. One sees from these curves—that is, the



Lowering in centimetres.

Ia, IIa } Height of solenoid 7cm.

Ib, IIb } Height of solenoid 3·5cm.

FIG. 1.

undotted curves I*a* and I*b*—that here the maximum attraction takes place when the lower edge of the core coincides with the lower edge of the coil, and it gives accordingly for a core which is six or twelve times as long as the solenoid the same result as Böttcher found for cores which had twice and three times the length of the coil. Also the result of Hankel's investigations with a core of eight times the length of the helix agrees with these.

Hence it appears that with cores whose length is double that of the coil, or more than double, the position of maximum attraction is always nearly the same, and this is when the end of the core coincides with the end of the coil.

* Abstract from a paper by Dr. Th. Bruger, of Darmstadt, in the *Elektrotechnische Zeitschrift* for May, 1886.

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Further experiments showed that the maximum point of attraction with a cylindrical core was the same for all strengths of the current, as might be expected. The two dotted curves, II*a* and II*b*, refer to experiments with a conical iron core instead of the cylindrical one.

The author's experiments in the case of a double cone confirmed what Böttcher said, namely, that the action was little different from that with a cylinder.

We may, however, regard as an improvement the introduction of a long single cone as core in the lamp regulator, for here the zero of attraction does not take place at the coincidence of the middle of the core and the middle of the solenoid, but more towards the thicker end of the core.

Arrangement and Method of the Experiments.

The following is the description of the apparatus employed, which is represented in Fig. 2 :—

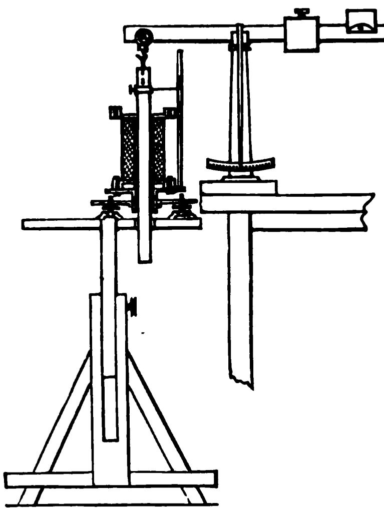
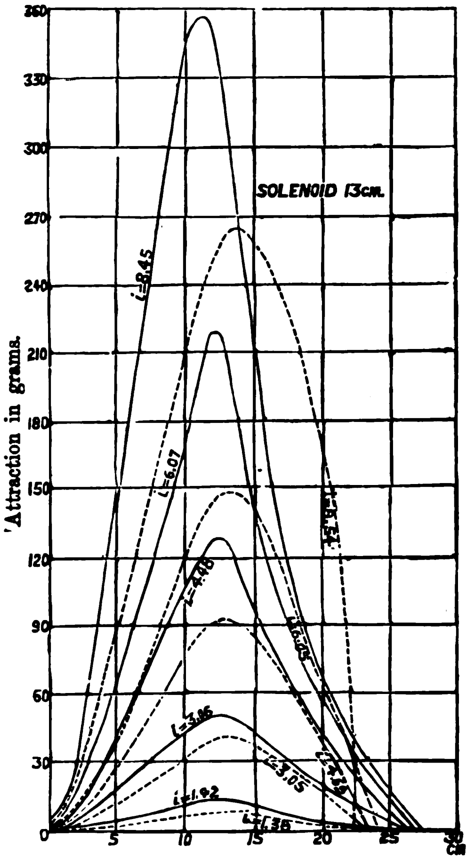


FIG. 2.

On a little wooden table with a board with a hole in it, which could be raised or lowered vertically, stood a brass plate, provided with three levelling screws, into which, again, a little removable brass table was screwed. The brass plate and the little table were also bored through in the centre, so that the iron core, hanging to the beam of a pair of scales, could conveniently pass through without touching from any slight vibration. On the brass cover was again a vertical silvered scale divided into millimetres, on which one could read the sinking of the iron core into the coil. The balance, which like the rest of the apparatus was specially fitted for the purpose, was constructed like the well known Mohr's balance. There was a weight, which could be moved along the arm and fixed in any position by means of a screw, and this was used to balance the iron core exactly when there was no attraction on it—that is, when the coil had no current in it. The attracting force of the solenoid was measured by brass weights pushed along the scale beam, which had divisions on it. The relative position of the solenoid and iron core was read off on the above mentioned scale, by means of a pointer, which could be screwed on to the core under consideration, and had edges over which the scale was viewed. The determination of the attracting force took place in the following manner :—First of all the position of the core in the coil was read off when there was no current passing, and then on closing the circuit weights were added to the longer arm, so that equilibrium was again obtained when the coil and core had the same relative position. Care had to be taken that at closing the circuit the core was not suddenly drawn down deep into the solenoid, but that the motion was at once stopped, so that its position was little altered. Otherwise a too strong magnetisation took place, and the value of the attraction for the point under consideration was too great.

Comparison of an Iron Cylinder with a Double Cone.

The cylinder was 39 cm. long and 1·5 cm. thick, whilst the somewhat shorter double cone had at its centre, or common base of the two cones, a diameter of 2 cm. and at the ends of 3 mm. The solenoid used was that of a Schuckert arc lamp. It had a height of 13 cm., and was wound with 2·6 mm. copper wire in seven layers each of 38 windings. The attraction on the two cores was determined with five different current strengths, from about 1·5 to 8 amperes. The results obtained are indicated in Fig. 3. The dotted



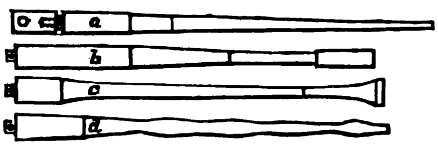
Lowering in centimetres.

FIG. 3.

lines here refer to the doubly conical, and the plain lines to the cylindrical core. A consideration of this diagram shows that a similar result to that of Böttcher was obtained. A double cone is not a core of constant attraction, and its action differs little from that of a cylinder. The points of null and maximum attraction have the same positions with both cores, and no advantage worth mentioning is obtained by the exchange of the cylinder for the double cone. The curves retain their form with different current strengths, and the two characteristic points do not shift their places.

Comparison of an Iron Cylinder with an Iron Cone.

The cylinder was the same as in the preceding experiments. The cone, provided with a cylindrical top, belonged, like the solenoid, to an arc lamp. It had the same weight as the iron cylinder, and is represented in Fig. 4*a* of a quarter the natural



FIGS. 4*a*, 4*b*, 4*c*, 4*d*.

size. The curves given in Fig. 5 again represent the attractions with five different current strengths, the highest of which about corresponded to that actually used in the arc lamp. It can be seen that the single cone has an advantage over the cylinder, since the curve is flatter. It should be straight, and parallel to the axis of abscissæ for the attraction to be actually uniform. With the single cone there is a slight shifting of the point of maximum attraction as the current increases. It can be

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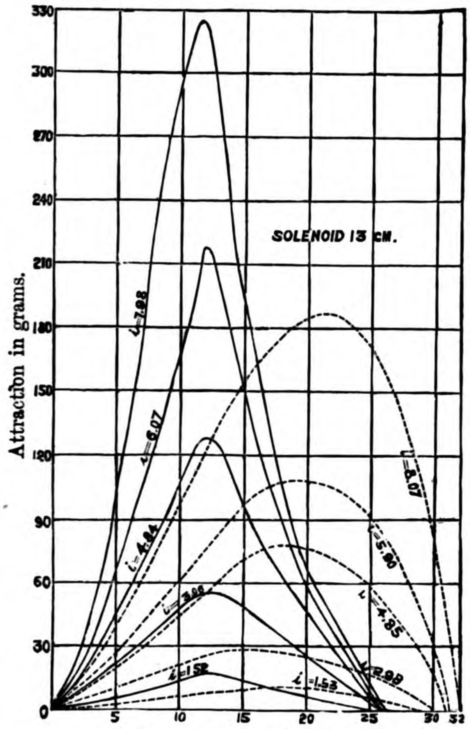
seen that with increasing current strength the point of maximum attraction retreats from the under thin end of the core towards the upper thick end. The reason is to be found in the greater mass of iron at this end. The shift in the position of the null point of attraction is small compared with that of the maximum point, but it appears as if with increasing current strength it inclined to take up such a position as to occur when the centre of gravity of the cone coincided with the centre of coil.



Lowering in centimetres.
FIG. 5.

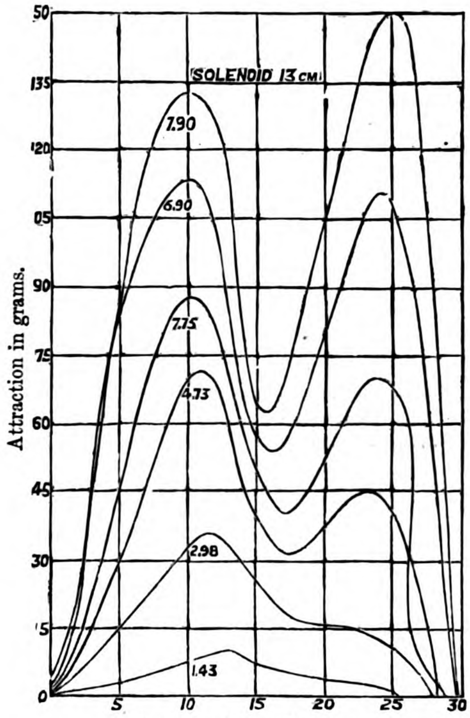
It appears from the foregoing that, though the single cone has a more constant attraction than the cylinder or double cone, this attraction is still very far from actually constant.

Experiments on a Form of Core lately proposed by Krizik.

These cores are made by adding together cylindrical and conical pieces of iron, and the attraction curves for two of them show comparatively favourable forms, in that for a distance of about 7cm. they run in a straight line parallel to the axis. The author made experiments with a core of the form shown in Fig. 4*b* (which is here shown of a quarter the real size), and the attraction curves with different current strengths are shown in Fig. 6. It can be seen that with such cores of complicated shape the whole form of the attraction curve alters with alteration of current strength. The reason is that the saturation of different parts of the core corresponds to different current strengths. With such a core, therefore, we shall have a favourable result only for near about one particular current strength. The limits between which this constant attraction occurs are very narrow, and this is still the case even for Krizik's best result with a core rounded off below in a parabolic form; for here the attraction is constant only for a distance of 7cm. Besides, this core would not suit an arc lamp regulator, because the current was too weak. In the experiments here described, the same solenoid was always employed, which was about 13cm. high. It became of interest to determine the attraction of solenoids of other dimensions on these irregular forms of core, and the core was consequently subjected to the action of two coils whose heights were the half and then the quarter of that initially employed. Here, as was the case before, the most favourable results were obtained with a current strength of 3 to 4 amperes. The whole type of curve is little altered, yet it appears as if better results might be here obtained with short coils, for the parts parallel to the axis become somewhat longer. But naturally the actual value of the attraction was diminished.

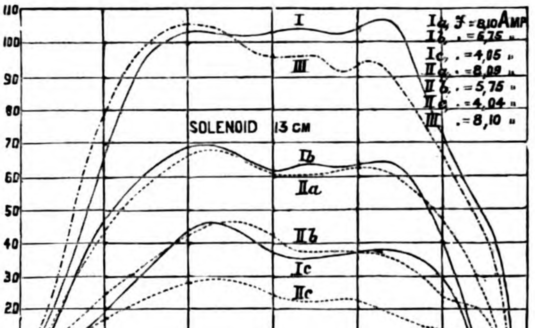
Next a core of the form shown in Fig. 4*c* was tried. This form was decided upon for theoretical reasons, and did not give very satisfactory results.

After a long course of experiments with cores of somewhat different shapes, the author finally arrived at the form shown in Fig. 4*d*, and obtained with it the plain (*i.e.*, not dotted) curves shown in Fig. 7. These curves are not straight and parallel to the axis of abscissæ; but they are more nearly



Lowering in centimetres.
FIG. 6.

so than the others for a certain distance. It might be possible to make the curve still straighter by further altering the form of the core, but the experiments are tedious. The rendering of the curve uniform is much easier for small than for large currents.



Lowering in centimetres.
FIG. 7.

The dotted curves II*a*, II*b*, II*c* refer to cores of cast iron, and curve III. to another wrought iron core of much the same shape as I., but rather lighter in weight.

The attraction with cast iron is not so great as with wrought, but the form of the curve seems to be independent of the kind of iron.

ELECTRO-PLATING WITH PALLADIUM.—*L'Electricien* states that M. A. Balle, of Besançon, has succeeded in depositing palladium upon iron and steel by electrolysis; but no details of the method are given. The coating obtained is said to be perfectly adherent, and so fine and hard that after removal from the bath no further treatment is required, and the process may be applied to finished articles.

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ELECTRIC STREET CARS.

By the courtesy of the editors of the *Electrical World* of New York, we have been favoured with an advanced proof of the following paper, which was read by Mr. T. C. Martin on Dec. 7, before the American Institute of Electrical Engineers :—

"The struggle for supremacy in this field of occupation may fairly be said to have narrowed itself down to three competitors—the horse, the cable, and the electric motor. Steam used directly is, it seems to me, viewed with more and more disfavour as the years go by, and has within city limits come to be considered very much in the light of a nuisance. The lowest cost of operation per steam motor per day, in usual service, that I have seen quoted authoritatively is $8.50 and $7. But even if steam were cheap, there are grave objections on the score of noise, smell, and dirt. The mere fact that steam locomotives have been in successful use 50 years, but are still denied employment on the streets, tells its own story as to public opinion. To some of us the banishment of steam even from the tracks of elevated roads seems a matter of but a few years. As for gas, soda and compressed air motors, I am not aware that they offer any points of superiority over steam for the specific purpose under discussion.

"Coming to horses, we find that in spite of their universal use and their faithful performance of duty, they inspire a discontent anything but complimentary, yet hardly to be wondered at. The statistics of horse cars are important and interesting, and deserve our attention as covering the sphere within which the electric motor will operate. There are, according to the latest returns available for this year, about 625 street railways of all kinds in the United States and Canada. Taking of these 408 horse roads giving full and trustworthy figures, I find that they run 17,331 cars and employ 85,888 horses. If at the same ratio we took all the horse roads, upwards of 500, we should arrive at a result of not far short of 25,000 cars and 150,000 horses, a total that probably comes very near the actuality. Taking the other figures, which I have tested by three sources of information, it appears that the horse car lines are maintaining a proportion of at least five horses to each car. But that is inclusive, and making a reasonable allowance for the use of different cars for winter and summer, and for idle cars, as well as for 'doubling-up' in heavy snows, a result is shown of at least eight to ten horses per car.

"The costliness of horses may be arrived at in yet other ways, by the use of comparative figures. Mr. T. C. Robins, of Baltimore, a street car expert, gives the average cost of horse car per day at $6.50. I have had the same figures given me for Brooklyn and Philadelphia. Mr. C. B. Holmes, of the Chicago Cable Railway, who has had great experience with horse service, says that the expense per car mile by the cable system is 10 to 11 cents, as compared with 20 to 25 cents per mile when employing horses. On a daily run per car of 50 miles, that would be at least $12 per day with horse traction, and half as much for cable. Moreover, there are the great extent of valuable land required for huge stables and the heavy depreciation of stock. Few occupations are more exhausting to horses than street car traction, and the average railroad life of a horse is but three to five years. In other words, out of 100,000 horses, at least 20,000 every year die or become useless for their work, and drag out the remainder of their existence in other occupations.

"The cable has already made its way into use on a large number of street railways doing a heavy business, and is, it must frankly be admitted, a vast improvement on old methods. It has enabled those roads to handle a traffic that was utterly beyond their capacity before. It has accelerated speed, has lessened accidents, has given the streets a cleaner look, has, it would seem, cut down expense, and has certainly raised the value of property wherever put in. But I doubt seriously whether in view of the enormous first cost of the cable system and the excessive waste of power, it will make very rapid strides, especially when subjected to the rivalry of electric motors. At the recent street car convention, the new cable roads at Kansas City were presented for favourable notice, and as they were evidently considered good specimens, let us accept the figures. The Metropolitan road will cost $50,000 per mile of single track, and I observe that it is claimed with regard to the Philadelphia system that the track there could now be duplicated at about the same cost. The Kansas City Cable Company gives some interesting results of a test of its engines and machinery, from which I gather that with a total of 159·7 horse-power, no less than 119·06 horse-power was required for the cable machinery, leaving only 40·64 horse-power for cars and passengers. In other words, just 25 per cent. was available for actual traffic. This waste will strike electricians familiar with the high efficiency of dynamos and their transmission of power as extraordinary. But it is confirmed by a statement from Mr. C. B. Holmes, of Chicago, who says that his cable railway required for ordinary operation engines of 477 horse-power ; that it took 389 horse-power to move the cable and machinery, and that 88 horse-power, or only 18½ per cent., was used for the propulsion of the cars at nine miles an hour. Mr. W. W. Hanscom, in a careful review of the conditions applying to the cable lines of San Francisco, gives a total daily average percentage on the seven roads of 68 per cent. of power for moving the cable, and 32 per cent. for the cars and passengers. Two miles of new double-track in San Francisco, fully equipped, have just cost $400,000.

"I do not know that these figures call for comment, as those presented later on in regard to electricity will serve for purposes of comparison. But they may be supplemented by one or two observations. It is evident that there is an objectionable rigidity in the cable system, and that it has narrow limits of applicability. A cable road, of whatever kind, needs a very large patronage. Mr. P. A. B. Widener, well known in connection with Philadelphia street railways, said last year :—'To maintain a cable road you must have a certain amount of business in order to be self-supporting. It costs as much to run the cable for half a dozen cars as for half a hundred. Small roads, or feeders to the main line, are run more cheaply by horses.' It will be remembered that great trouble was experienced in Philadelphia in rendering the cable system there operative last year. The assertion is made by those who should know that 12 miles, costing between $40,000 and $50,000 a mile, required $250,000 in repairs and renovation inside the twelve months.

"We New Yorkers have learned that the cables wear out quickly, besides being ceaselessly noisy and requiring a conduit that must have such depth as to become an unhealthy drain or sewer.

"We reach now, in the due course of our survey, the use of electricity as compared with horses or cables. You will, I believe, bear me out when I say that the confidence of electricians in the ability of electrical means to propel street cars is as strong as it could possibly be, and is moreover based on no small amount of work and experience. I might affirm that the general introduction of electric motors is now largely a question of coal bills. I might affirm that it has more and more resolved itself into a question of mechanics ; and in both statements I should have your concurrence. I might broadly state that in Europe, where a large number of electric roads exist already, they are paying well and multiplying ; and that such roads in this country had, some months ago, carried altogether over a million passengers, or a daily traffic of 3,000 passengers for a full running year, without any recorded injury to a single patron, while several new roads have of late gone into successful operation. But at the risk of covering much ground with which you are familiar, I shall venture to give an outline of some of the methods by which electricity is applied to street-car service, as well as some of the data establishing its claim to superiority. I do not know of any point on which a fair comparison need be shirked ; I do not know of any difficulty that can tame the infinite variety of our electric art, and as this society has never hitherto had the subject before it, I am encouraged to go a little into detail.

"We have, in using electricity for street cars, the option of so many methods that the very flexibility of the application becomes a recommendation. We shall, perhaps, best spend our time in considering three or four of the leading methods, with incidental reference to the peculiarities of individual cases in each. I propose to take the third rail system, the overhead system, the conduit system, and the storage system, and, without any intention of invidious discrimination, to pick out, for the exemplification of each, some of the roads and cars that have been running or can be seen and tested.

"Let us begin with the third rail system. The Daft road at Baltimore, now in its second year, has been so often described that full details are not here necessary, but it furnishes some interesting figures. The cost of electric power there against horse-power at $6.50 per car has been $4 per car per day, with an increase for the year of 83,986 passengers. Mr. T. C. Robbins reported as follows to the street car convention :—'It was started on a purely commercial basis, as a purely commercial transaction, and has continued, and is now being extended, simply because it has proved its right to stay by the performance, which leaves little to be desired.' The largest item in the expenses at Baltimore is coal at $3.50 a ton. Another third railroad, the Highland at Detroit, on which there are none of the grades and curves that rendered the Baltimore road expensive as to fuel, is in very successful operation. Like the Baltimore road, it has a wheel for making contact ; but, unlike it has the third rail neatly sunken between planks. It runs out of the city for three miles. The car in use is the same as those on Broadway, this city. Mr. Frank Fisher, whose motor is used, informs me that on a recent Sunday, on a thirteen hour schedule, the road carried 5,500 passengers. The coal consumption was a little over 400lb. The coal—screenings—cost $1.25 a ton. The success has been so great as to lead to a development of plans matured for the increase of the surface there and on a local road to be begun in the spring.

"You will agree with me, I think, that third rail systems must be limited to a low electromotive force, and to surburban or rural districts. Even there they have a large opportunity.

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"Coming to the overhead conductor systems, the Van Depoele roads form an important group. These roads are now in operation at Detroit, Port Huron, Mich., Windsor, Can., Appleton, Wis., Montgomery, Ala., and Scranton, Pa. Mr. Van Depoele suspends his feeding conductor by side poles, or, as at Appleton and Scranton, has double wires, corresponding to the track, but immediately above it at a height of 18 or 20ft. The little Windsor road, two miles long, with two cars, started in June, 1885, has paid for itself. The Appleton-road, with five cars, is the first in this country run by water-power, depending, and with great success, upon a pair of turbines that will develop 100 horse-power, and are now driving a 60 horse-power dynamo. The Montgomery-road is notable as being a complete city system, including ten miles of track. The Scranton-road that started last week has two features of special interest. One is that in a city of about 50,000 or 60,000 inhabitants the use of the overhead conductor is allowed. Another is that the line is operated from the electric light station. The road is 2½ miles long, with 12 grades, mostly over 6 per cent. There are already in use two heavy Pullman cars, running at a speed of from 4 to 15 miles an hour. The current is conveyed by a conductor $\frac{3}{10}$ of an inch in diameter, the rails forming the return. A traveller with rollers and a flexible cable passes the current to the motor, which, it is worthy of notice, stands upon the front platform in sight of the driver. The electric light station is well satisfied with only $9 a day for running the 60 horse-power generator, and it is evident, therefore, that an increase of rolling stock will involve very little increase in cost of power. Here is a hint by which electric light men nearly everywhere might profit.

"The overhead bare conductor systems are also restricted to currents of low electromotive force. But they, as well as the third rail systems, do work it is impossible to perform remuneratively by cable, and which would often be beyond the range of horse or mule power on either philanthropic or business principles. Provided permission is obtainable for running the wires, the overhead conductor system seems cheapest, if not best, for cities up to at least 50,000 population. I believe a double overhead conductor system well built should cost from $1,500 to $2,000 per mile. The single conductor is, of course, much cheaper.

"There are in the United States about 40 cities with population above 50,000. In almost every one of these it would be necessary to resort to the electric conduit system, third on our list, unless the storage system be tried, or a combination of the two. At the present time, the outlook for electric railways with conduited mains is very favourable.

"The first exemplification of a conduit system in this country was given by the Bentley-Knight Electric Railway Company, in 1885, at Cleveland."

[In order to save space we omit the description of this system, which we have recently dealt with at length.—Ed. *E.*]

"The company makes a completely equipped steel-framed truck, with motor, &c., upon which can be placed any car body. These have a wheel base of 6ft,, a standard gauge of 4ft. 8½in., and can be used on curves with a radius of 45ft. A motor of the Gramme type is used under the car. For long distances the motors are in series, with current constant; for short distances, the motors are put in multiple arc, and a new form of resistance is used. Such are the main features of the system. Of its eminent practicability there should be no doubt. The question again is one of expense, and I therefore give transcripts furnished me by Mr. R. W. Blackwell, of actual estimates submitted quite recently and now under consideration. The first is for the equipment of existing street railways in the City of New York, 3 miles 1,440ft., double track, minimum headway 1½ minutes, average speed seven miles per hour, running 24 hours per day, very heavy traffic, maximum grade 3 in 100.

"*Construction and Equipment.*—Conduit and conductors, 34,560ft., at $3, $103,680; motor trucks, 37 at $12.00, $44,400; 50 horse-power dynamos, 12 at $2,500, $30,000; steam power plant complete, $27,750; foundation, $5,000; engineering, $3,000 —$213,830.

"*Annual Expense.*—Coal, 14 tons per day, at $3, $15,330; engineer and assistant, at $2.50 and $2 per day, $1,642.50; firemen, 3 at $1.50 per day, $1,642.50; machinists, 2 at $2 per day, $1,460; total rnnning expenses, $20,075. To which should be added interest on construction cost ($213,830) at 6 per cent., $12,829.80; and also depreciation of plant at 3 per cent., $6,414.90; total expense and charges, $39,319.70.

"The second is for a down town cross-town road in the city of New York, greatest grade 1 in 12, double track; 12,660ft. conduit (extra heavy), at $4, $50,640; 20 motor trucks complete, at $1,200, $24,000; six 50 horse-power dynamos, at $2,500, $15,000; steam plant complete, $20,000; foundation, $2,000; engineering, $2,500 —$114,140.

"Of course, I do not present these figures as those upon which all authorities are agreed, but they have their value as being bids on actual work.

"In the conduit system of Mr. W. M. Schlesinger, in use for four months past by the Union Electric Company at Philadelphia, with a car running 9¼ miles an hour, the motors are intended to work in multiple arc.

"There are other conduit systems, among which I might mention the Van Depoele used at Toronto, I believe, in 1884. In the cable system, with its costly conduits, the available power for the cars and passengers reaches only about 25 per cent., in the electric conduit system, requiring for generators, conduit, and conductors, &c., but half the outlay necessary on cable system, the net return of power reaches at the minimum from 50 to 60 per cent. Mr. G. W. Mansfield, who has had considerable experience with the Daft Company, puts it as being at least 56 per cent. I note, too, that with the use of the Holroyd-Smith conduit system the Blackpool road, England, has reported earnings of $1,735 in a week, with a total expense account of $225, running 2,760 miles and carrying 44,306 passengers.

"A distinguishing feature of the conduit system is that it is the only one with which high potentials can be employed on the streets. With it, also, the power stations can be placed near ample water supply or where rents are low, or can each be given a section of road to operate.

"I approach the next and last system on our list, that of storage, with some degree of nervousness. In more than one quarter the man who comes out with a kind word for the secondary battery is set down as either a knave or a fool. I cannot see why he should be regarded as either, although he may perhaps be more than ordinarily sanguine and hopeful. I understand that storage is to be extensively used at an early date by the North Metropolitan Tramway Company in London. At Antwerp, in 1885, after six months' competition with four other cars using either steam or compressed air, the Julien electric storage car took the first prize, awarded by a jury of well-known experts. There were in all twenty-three points of comparison. The Julien car has since been tried in Hamburg, and another has been in operation on the Eighth Avenue line in this city. The question is as to the cost of maintenance of the cars and the furnishing of motive power. It will be admitted that there are advantages in having each car an independent unit, offsetting the disadvantage of carrying the dead weight of batteries; and that single cars on any road can be taken in hand for change, so that existing rolling stock can be progressively adapted to the new conditions. This involves a smaller initial outlay, and gives opportunity to train the present force in its unfamiliar though simple duties. Now, regarding first cost—I have never seen any figures as to the expense of an equipment of a car with storage batteries. It has been said that two sets for an ordinary street car would cost about $1,500. That seems high. The Julien Company states that the cost of the horses for a car more than covers the initial outlay of the change, and I believe the firm estimate is also made by the company of a total daily running expense of not to exceed $5 per car in cities on heavy traffic. As to life of the batteries, those in the Hamburg Julien car have now been in daily use since April, and they show a return of 71 per cent. of the power with which they are charged. The car is running on regular daily service. In respect to American storage batteries, it may be mentioned that the Electrical Accumulator Company, whose officers have a high standing in electrical circles, guarantees two years' life for its new battery and an 80 per cent. return of power.

"Putting it broadly, the storage system, in spite of its various conversions of energy, has a superiority of at least 25 per cent. over cables. Some of you will put it far higher, but as I have said, in the absence of the data of prolonged work, I prefer to put it low.

"I think we shall see a number of efforts shortly made in the direction of using secondary batteries for regular work on street cars, and the results will merit our most careful study. There are, moreover, some ingenious propositions for combining the conduit and storage systems, so as to enjoy the benefits of both. Mr. J. M. Pendleton has described a plan of his of this nature, and Mr. Elias Ries, of Baltimore, has also carefully elaborated such a system, in which storage plays an important part.

"Here, then, illustrated in a variety of ways and by numerous examples, we have a comparison of electricity with other power for propelling street cars, and an idea is given, very imperfectly, of the wide range of choice that electricity itself offers as to methods and means. Much of what has been said has its direct and favourable bearing on elevated railway traction, as well as on that for underground railways, but the time will not permit me to pursue the subject any further. Many points of discussion arise as to the connection of the car axles with the motor; the use of independent motor cars or of motors on the passenger cars; the types of motors and of conduits or conductors; the potential that is safe under certain conditions; the methods of regulating motor speed; the use of resistances; but all these and others I may leave to you, many of whom are doing practical and creditable work in this field, and who by thus 'hitching your waggon to a star,' have

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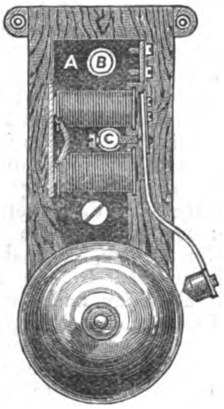
shown that street cars, if run by electricity, may yet be brought up to the most advanced notions of humanity, comfort, convenience, and economy."

ELECTRIC BELLS.

In the articles contributed to this journal six years ago by Mr. Walker Moseley, he described a short circuiting electric bell which he stated he had made and fitted up exclusively in all the installations of electric bells carried out by him since 1873. In spite of the special advantages offered by such bells, the great majority of electric bells continued to be made of the old type, which was first known and for a long time called the "French trembling bell." It was generally alleged that the action of the bell hammer in Mr. Moseley's bells was not so good as in the old sort. This was practically correct, and the only question was whether the other obvious advantages outweighed the one disadvantage. Mr. Moseley gave reasons for concluding that they did, but he has since found that the defect can be obviated, and he designed and patented an improvement last August which is now introduced into the trade.

In Mr. Moseley's former design the contact made by the armature with the short-circuiting spring was effected between the electro-magnet and the bell hammer, as close to the electro-magnet as was practicable. In the new improvement this is done—as will be seen in the illustration—between the two bobbins of the electro-magnet, and instead of the armature making contact against a spring, the spring is attached to the armature and makes contact with the end of the screw in the terminal C.



The spring usually made solely to carry the armature is continued along the back of the armature as far as the screw, and furnished the necessary spring contact with the said terminal, a hole being made through the armature to allow the end of the screw to touch the spring through the said hole. The short-circuiting terminal C is insulated from the iron base A. The terminal B is also insulated from the iron base A, but B and C are metallically connected together under the base A. One end of the wire on the electro-magnet is connected to the iron base, the other end is connected to the terminal C. Hence it will be seen that when a current is sent through the electro-magnet it will attract the armature, until the armature spring touches the end of the screw which allows the current to pass directly through the terminal B, thus cutting out the electro-magnet.

The impetus of the armature causes it to strike sharply against the ends of the electro-magnet, and propels the bell hammer against the bell, the spring on the armature effects a sharp repulsion, and when the contact-making spring leaves the contact the electro-magnet repeats its attraction as before. Although the action described is so contrary to that in the old kind of bell, the effect is apparently quite as forcible. In this form of bell there seems little chance of failure through oxidised or dirty contact with the "make and break" spring; and a service of bells may be included in one circuit. When used with indicators, as the electro-magnet is cut out the indicator is actuated by the full current, and is less likely to fail than in the old form.

The bell from which our illustration is drawn was made by Mr. Lewis, 37, New Oxford-street.

Electrification of Ice by Water Friction.—In some recent experiments by L. Sohncke a jet of water was caused to play against a sheet of ice at a certain angle. It was then found that the lower part of the jet was electrically positive to the water which had just struck the ice. In most cases water becomes positively electrified by friction with a solid. The author considers that his results are opposed to Edlund's theory, in which the usual + electrification is ascribed to a straining of the ether caused by the forward motion of the stream of liquid. Tin, steel, and glass, when rubbed upon ice, produce a + charge in the latter.

GLOW LAMPS, THEIR USE AND MANUFACTURE.

BY MAJOR-GENERAL C. E. WEBBER, R.E., C.B.

(Concluded from page 132.)

Users of glow lamps will be interested in the table shown, which is an average of several tests of the lamps of two or three makers :—

Mean current and candle-power of two long-lived 100-volt 17 candle-power lamps of different makers, run at 100 volts, and tested every 100 hours.

		Current	C.-P.
Initial current		·63 a	18·5*
After	100 hours	·65 a	18·8
,,	200 ,,	·65 a	20·7
,,	300 ,,	·65 a	18·5
,,	400 ,,	·65 a	18·5
,,	500 ,,	·65 a	18·5
,,	600 ,,	·65 a	18·
,,	700 ,,	·65 a	17·5
,,	800 ,,	·64 a	15·5
,,	900 ,,	·64 a	15·2
,,	1,000 ,,	·64 a	15·2
,,	1,100 ,,	·64 a	15·2
,,	1,200 ,,	·64 a	15·2
,,	1,300 ,,	·64 a	15·2
,,	1,400 ,,	·64 a	15·2
,,	1,500 ,,	·63	13·7
,,	1,600 ,,	·63	12·7†

* 3·4 watts per C.-P. † 5 watts per C.-P.

This gives a little history of the changes of the filament during its life. The tale told may be summarised as follows :—That during the first 200 hours the resistance decreases slightly, with consequent increasing brilliancy. These conditions remain nearly stationary for the next 500 hours. After that they alter perceptibly, increasing in resistance and decreasing in brilliancy in a progressive ratio. But it must not be forgotten that the increase in resistance of the filament is not the sole cause of the loss of light. As the filament ages, its original smooth surface roughens, and is consequently increased in area in larger proportions than it would naturally be decreased by the loss of bulk. The larger surface requires more current, whereas the increased resistance is gradually reducing the supply. Another cause of the loss of light is due to the blackening of the glass by a carbonaceous deposit, which also increases with age. This latter loss in 1,000 hours' consumption amounts, in a good lamp, to 15 per cent. This clouding over of the lamp bulb is due to an internal deposit due to the disintegration of the material, either of the wire mount or of the filament.

Dr. Fleming gave the Physical Society in 1883 and 1885 a description of some curious phenomena incidental to this aspect of the use of glow lamps. It is sufficient for our purpose to mention the cause and the effect. As time goes on in the life of a glow lamp a smoky deposit is apparently inevitable; but, quoting Dr. Fleming, "In normal use, when the lamp is not being pressed beyond the E.M.F. at which it is intended to be used, there is a general evaporation of carbon going on from all parts of the loop." His experiments tended to show that when an excessive temperature is given to the filament by a higher E.M.F., the molecules are projected with violence against the glass, causing by the more rapid disintegration an earlier obscuration of the globe than should arise under normal conditions of consumption. The rate at which the clouding takes place is rapid in the case of some defective filaments. But as a rule makers have conquered this difficulty, and it takes place under conditions which are preventible. The loss of light is very slight, and the appearance of a clouded lamp by daylight is, I think, its most objectionable feature.

Any user of glow lamps on his own installation will find, when he replaces old ones by new, that the latter will give more light, so that if he introduces a new lamp to replace one which has been broken at a period when most of the lamps are, say, 900 hours old, he will perceive a difference of about two or three candles if he uses 17 candle-power lamps. If the old lamps are, say, 1,700 hours of age, he may find a difference of seven or eight candles. As the current is not economised in proportion to the loss of light, he should recollect that a point may be reached when, by continuing the use of old lamps, there arises an important waste of power. Hence the public should judge of the efficiency of lamps outside certain limits more by their constancy of candle-power rather than by their length of life. Thus the best lamp is that which lives the longest with least variation of light.

Next we may consider the test for vacuum, which in a laboratory can be made with the induction coil as already mentioned by the following test: Hold the lamp in one hand, and bring the leading-in wires in proximity with the pole of a high potential induction coil. If the vacuum is bad, a considerable glow is visible inside the bulb; if good, the glow decreases, and will be evidenced by the length of the spark between the coil and the wires, so as to be almost invisible, and the spark outside is very faint and short. The vacuum test may also be made by the measurement of heat, to which a lamp burning for a given time will raise a given volume of water in which it is immersed; but this test has one defect.

Another, but a rougher test, is one which is made by sealing off the lamp with a short length of the vacuum tube attached, and then cutting or breaking its end under mercury, when a bubble denoting the presence of air if it exists will be detected as soon as the mercury has risen into the bulb. The users may make an approximately good test, by observing the presence of luminosity when a lamp is rubbed with the fur of a cat's skin in the dark, or by the touch. The temperature of the external surface of the bulb after it has been alight an hour or so, will show undue heating which will signify the existence of a bad vacuum. The scientific test of the candle-power of these lamps involves us in the form of photometer to be used, and above all the standard of light. The latter is a question which is

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still under the consideration of a committee of the British Association. It appears to me that it is not much nearer decision than it was when brought before the Congress of Electricians, at Paris, in 1882, when the Carcel lamp and the candle still had their supporters, but there may be members of the committee present who can enlighten us thereon. For manufacturing purposes it is the practice, as I have shown is done by Dr. Fleming, to use standard glow lamps, which are frequently renewed before they have time to deteriorate. These standards are obtained by photometric comparison with flames or sections of flames of known value ; ultimately referable to an average of a series of tests with the standard sperm candle. But when it comes to competition tests between the lamps of various makers, that which is most relied on is the life test, for although that test is also a trial of the carbon it is now generally understood that most fairly well constituted filaments will live in a really good vacuum. To consumers the life test is a matter of economy. They can easily be brought to understand that if their lamps are used with a higher E.M.F. than that for which they were made,

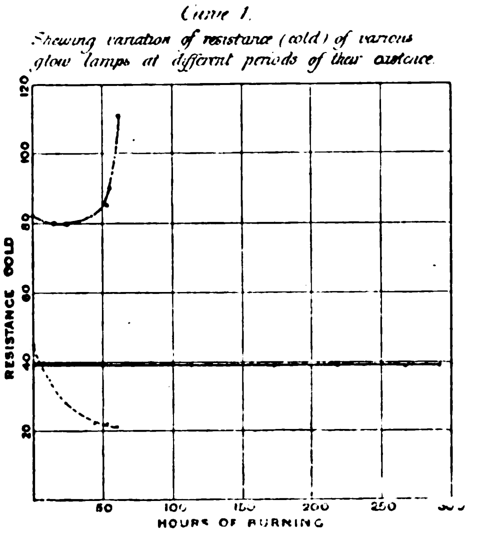

FIG. 5.

over-incandescence takes place, as well as the "clouding" already referred to. This is commonly called "overrunning" lamps, and it is very easily brought about by want of arrangement at the source of the current to secure regulation of the pressure. Often the purchaser of lamps condemns them for their short life, not knowing that all along it is his own fault, and that through frequent over-incandescence his eye has lost the power to judge, even approximately, of the candle-power he is extracting from them. It is not to be expected that he should have a photometer in his house to check this, but it is not too much to require him to have a voltmeter at a point where he may occasionally test for himself, whether the potential between his mains is dangerous to the endurance of the filaments in his lamps. If, however, his lamps behave as those did as shown in the table already mentioned, he should observe his voltmeter with the view to underrun them in adolescence, so that a healthy maturity and vigorous old age may follow. There are those present to-night, I believe, who can give the audience very interesting information on these matters.

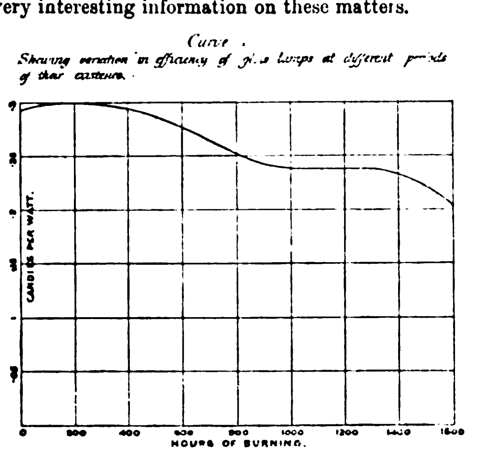

FIG. 6.—(We are indebted to the Editor of the Society of Arts *Journal* for these and the previous illustrations.)

In some lamps defective cementation of the filament to the wire mount, shows itself after a short life, by a giving way or a fracture at that point ; but no eye-test can, beforehand, detect the liability to this fault. It is still that there is a greater tendency to give way at the junction with the negative metal pole, and from this it has been suggested that when alternate currents are used, their liability to failure would be modified. It will be very instructive if some one of my audience can enlighten us this evening as to the effect on filaments by the use of alternating currents.

Time does not allow of my touching on several points of interest in connection with glow lamps, brought before electricians in late years by Mr. Wilhelm Siemens, of Berlin, by Crouto, of Milan, and by Bernstein in this country. I trust my audience will realise that my object this evening has not been to enter on too technical or debateable ground, but rather to engage their interest in the subject from its industrial point of view ; and that they will also look with approval on my abstention from touching on the patent and legal part of the question, which has so long been, and still is, a matter of controversy.

Major-General Webber requests that the following corrections may be made in his paper on "Glow Lamps":—Instead of "no further precautions are necessary," read *no further precautions to prevent arcing are really necessary.* Instead of "which unreasoningly insulates the wire which need not be in a state of electrical tension, as well as that which is always ready to discharge," read *which unreasoningly insulates that conductor which need not be in the same state of electrical tension as that which is always ready to discharge into it.*

SOME EXPERIMENTS ON SECONDARY CELLS.*

BY JAMES SWINBURNE.

This paper is a very condensed account of a large number of experiments made in the spring of 1883.

About four years ago Mr. Norman Cookson, of the well-known firm of lead manufacturers in Newcastle, brought out a process for making lead in the form of fine fibre or hair. Mr. Cookson's method is this :—The lead is melted in a pot, which is raised some feet from the ground ; from the melting-pot is a tube which leads down some six feet, and ends in a rose like that used on a garden watering can. The fall tube is kept hot throughout its length, so that when the lead is melted in the pot it is not solidified in the pipe. The melted lead then flows through the fine holes in little jets, and these jets solidify in the air, and fall in a tangled mass like lead moss. Some care has to be taken to keep the lead in the pot, and in the tube at the right temperature; but this is the only difficulty, and the whole cost of the lead hair is not more than two shillings per ton above that of pig lead.

Those who were working at secondary batteries this time four years ago will remember that most people had the idea that the great thing to be aimed at was a very large surface. Mr. Cookson's invention, therefore, seemed most valuable, and he set to work with the energy which is his characteristic, especially when working at something new. Mr. Cookson made up a dozen large cells, which he sent to Mr. Jameson, the inventor of the coke process, who was then working at an incandescent lamp. Some of the lead hair was made up into little cells, and tried in various ways by Prof. Herschel, of Newcastle. Prof. Herschel published some account of his work in *Nature*. Mr. Cookson also made arrangements with the writer to go into the question of secondary batteries. The theory that large surface of lead was necessary gave way when the question of local action was more fully studied ; but after all it seems to be near the truth.

Some reason may be demanded for bringing before this Society the account of experiments which were made so long ago. Many of them have been made again since, and many are of no use at all ; but, on the other hand, there are a number which are still new, and the next best thing to knowing what to do is knowing what not to do. We made altogether more than three hundred different cells ; but, to prevent this paper running to too great a length, only a few of them are described.

Cells with Hair Lead.—The first were Mr. Cookson's large cells. These had four plates ; each plate was about 8in. by 10in. by 1in., and consisted of a sort of cage of sheet lead with holes in each side. The lead was joined by burning, no solder being used. The inside of the cage was filled with lead hair, a lead wire being arranged zig-zag through it, and burnt to the cage. Each plate was sewn in flannel. A battery of twelve of these cells was sent to Mr. Jameson to be charged. They came back to the lead works without any particulars as to what had been done with them. We therefore coupled them up with dynamo, and charged them in what appeared to be the opposite direction. They had 12 amperes through them for about seven hours a day for no less than five months, and even after three months gas was coming off the reduced plate only. The cells seem to have had enormous capacity, and must originally have been charged in the other direction. After three months the reduced plate gave off gas, but the peroxide plates went on charging for the whole five months. We did not try running them down to see what charge they really had, as other experiments which were going on at the same time led us to suppose that the local action would render them useless. Probably the surface of these plates was so large that the local action formed enough sulphate of lead during the night to utilise the current during the whole of the next day in oxidising it. At the end of the five months the flannel round the plates was not spoilt. This seems to show that it is not the acid that spoils the flannel in the Faure cells, but the oxidation due to the contact of peroxide of lead. Some experiments on organic substances with oxidising agents will be described presently.

The first difficulty to be overcome with the Cookson lead hair was making good electrical connection with the support. Various methods of soldering were tried, but the little wires of lead were melted off whenever it was tried to burn them to the back. Solder with a flux of caustic soda ran along the fibres too much. Various methods of connecting the fibres by pressure were tried. The material was woven into loose mats, and these were passed under large rollers. Every degree of density could be obtained in this way. Though the metal was clean, and appeared to stick together at first, it did not adhere as strongly as might have been expected.

* Paper read, Nov. 25, 1886, before the Society of Telegraph-Engineers and Electricians.

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The chief fault of the lead hair seemed to be the vice of local action. In those days local action was not so well understood as now. The theory seems to be this:—If lead and peroxide of lead are electrically connected, and any of the surface of the lead is exposed to the acid, that part of the surface is attacked, and a thin film of lead sulphate is formed which protects the surface from further corrosion. The lead is then in contact with the peroxide at some points, and with lead sulphate at other points, but is not touched by the acid anywhere. If the cell is charged further, the film of lead sulphate is oxidised into peroxide, so that the plate again consists of lead and peroxide of lead only. As the peroxide formed from a given quantity of lead sulphate occupies much less room, a small portion of the surface of the plate is again exposed, but is immediately coated with a film of peroxide; the result is that the whole surface of the plate is protected. The least movement seems to expose some of the surface of the lead to the acid. The lead can thus be protected by anything that prevents its contact with the acid. For local action to take place some of the lead must be exposed to the acid. If, while a cell is charging, a clean surface be made on the peroxide plate it will immediately be covered with a thin film of peroxide, which will protect the plate from further attacks. If, on the other hand, the dynamo is disconnected and a clean surface then exposed, it will be immediately covered with a film of sulphate which will protect the plate. Thus the plate may be protected either by sulphate or peroxide. When the lead of a plate is converted into peroxide the plate is being charged. When the lead is converted into sulphate local action is going on. In the large Cookson cells the fibres of lead were converted into peroxide during the day by charging, and more lead was converted into sulphate during the night by local action; so that it was unnecessary to reverse the batteries to secure more rapid formation, the formation being already rapid enough. Mr. Crompton told me this summer that he found that cells were practically indestructible if not discharged too much, and this seems to be the grand secret of successful work with secondary batteries. Messrs. Drake and Gorham mentioned the same thing in their paper read at the British Association this autumn. Either the peroxide of lead is so porous that it never quite protects the plate, or it is disturbed by small bubbles formed in the coating; for if a current is passed continually in one direction a lead plate is eaten into, as may be seen in a water resistance with lead electrodes—the oxidised plate seemingly does go on forming. In the lead hair cells the surface exposed was so enormous that a very slight formation was enough to demand a very large supply of electrical energy, so that the cells seemed to run down as fast as they were charged. No doubt the fault was that the fibres of lead used were rather too fine; if we had used much thicker lead wire we should have probably made a very good battery. Several plates were tried with hair lead, red lead, litharge, &c., but our ideas as to the validity of Faure's patent were not quite what they are now, so comparatively little was done in that direction.

Secondary cells are, however, tedious things to experiment upon. It may take a year or so to see what a cell is going to do. The best method is to keep several sets of experiments going on at the same time.

For the sake of conciseness some of each class will be given, arranged in groups.

Quick-forming.—Cells were made with lead hair in a solution of sodium chloride; the anode was quickly attacked, but the coating was not adherent, and came off in clouds; black clouds, presumably of finely-divided lead, came off the other plate.

Lead hair and potassium bichromate: seemed to oxidise well.

Lead hair and potassium sulphate: no very marked result.

Amalgamated lead in dilute sulphuric acid: the peroxide formed had little stiction or power of adherence, and kept peeling off and exposing the bright amalgamated surface; this happened especially on reducing.

The object aimed at was to get an electrolyte which partly dissolved the plate; the idea being that an action like that of which advantage is taken in the manufacture of white lead might be used in the quick formation of battery plates.

Lead in solution of sodium-thiosulphate: thick black mud of lead sulphide formed.

Amalgams of lead and 10 per cent. and 5 per cent. of mercury: coating had no stiction.

Alloy of lead and zinc: this was not so easily attacked as one might expect.

Lead hair in solution sodium hydrate and sulphide: the solution got yellow, and deposited sulphur on the oxidised plate.

Lead in solution of ammonium chloride: was no better than the similar cell with sodium chloride. No doubt a little nitric acid was formed, but the cell was not a success.

Cells were tried with solutions of potassium fluoride: The plates were not formed well.

Lead in potassium sulphides: not much attacked; the action of the sulphide seemed uncertain, and is partly dependent on the amount of hydrate present.

Lead plates in solution of salt, with felt between: after reversal this gave good spongy lead, but a great deal of the peroxide was loose and detached.

Lead with various mixtures of sulphides and carbonates and nitrates: none of these gave deposits which would reduce well—they were all too loose.

Lead in sulphuric acid: just diluted enough to make it conduct; the anode was not much attacked.

Lead in a mixture of sulphuric and nitric acids: more quickly formed.

Lead in nitric acid alone: eaten through very quickly. The action of nitric acid on a lead plate is very peculiar. Most of the solutions already mentioned attacked the plate evenly and oxidised it gradually through, but nitric acid makes pits and round holes. As nitric acid seemed by far the best means of quick formation, several experiments were made with it. Plates were eaten wholly through with acid which was too strong to dissolve much nitrate; the acid was then siphoned off and replaced by a solution of sodium sulphate and reversed. There was difficulty in reducing the lead sulphate; it formed cakes which did not make good contact with the plate. The great objection to the various methods of forming above described is that the coatings produced have too little stiction to reduce well. When lead was the anode in nitric acid no peroxide was produced. Of course no peroxide is formed when the plate is in contact with sulphuric and hydrochloric acids, as peroxide of lead liberates chlorine in an acid solution, while chlorine precipitates lead peroxide from an alkaline solution of the lead salt.

The best solution we tried for forming plates was a mixture of dilute sulphuric and acetic acids; this solution made a fine and adherent coating which reduced well. One of the most obvious disadvantages of such solutions as dilute nitric acid is the difficulty of getting rid of the least traces of acid; of course, traces of such things as nitric or hydrochloric acid in a cell may be very destructive, or they may be quite harmless. Acetic acid can easily be driven off as vapour, and nitric acid might perhaps be reduced to ammonia and then volatilised.

Mr. Brush heats his plates to accelerate their formation; we did not try this.

Local Action.—To reduce the local action in the peroxide element we tried amalgamating the plates; this did not act. We tried to gild lead plates, but did not succeed; a gold sleeve link seemed to act well as a support for a little peroxide plate, and it was hoped that gilding might preserve lead. We tried to protect lead by various sulphides. These experiments seem absurd; in fact, many of our experiments were rather wild; but the supposed method of protecting plates has recently been patented by no less able a chemist than the late Mr. Tribe. Lead was fused with various proportions of galena, and the resulting substances were tried as anodes. Galena itself is at once coated with lead sulphate when used as anode in dilute sulphuric acid.

Lead was also combined with arsenic by heating in glass tubes. This was very troublesome work, as the arsenic was apt to volatilise, and sometimes the tubes broke, and the laboratory had to be abandoned until the smell was gone.

Double sulphides of antimony and sulphur bases were tried, but were of no use. In our provisional protection, applied for in 1883, we mention coating the plates with lead sulphide by means of thiocarbamide. This idea was taken from a receipt seen in a copy of the *Plumbers' Times and Paperhangers' Gazette*, or some such paper, which was sent me with an intimation that I had no business not to take in my trade journal. Thiocarbamide could not be bought, and was too troublesome to make, so this plan was not tried. The process is said to produce a beautiful polished adherent coating of lead sulphide on lead, or even on organic substances such as netting, and is of very considerable interest, and perhaps of commercial value.

Silver was tried as peroxide plate in various solutions. It behaved very much like lead, though it is not so easily attacked by sulphuric acid; peroxide of lead sticks to it well, but of course it is too expensive for commercial use. Silver might be used for connections. Most metals exposed to the action of the spray from secondary batteries are attacked, and make bad contact, but silver may be laid across the top of a cell without tarnishing. Probably electro-plated copper would do as well. Very few experiments were tried with platinum because of the expense. Mr. Brush has patented plates made of an alloy of lead and platinum. Most likely it would take a very large proportion of platinum to protect a plate, as the alloys of platinum are easily oxidisable. No doubt Mr. Brush's invention is only waiting for the discovery of a platinum mine.

Local action may be a very serious evil in reduced plates, especially with strong acid. Local action on the reduced plate must not be confused with local action on the peroxide plate. It does not here take place whenever a clean surface of lead is exposed to the acid, but when a body sufficiently electro-negative to lead comes in contact with it, and enables the spongy lead to combine with the acid by evolving hydrogen from the electro-negative body. In some cases reduced plates in dilute sulphuric acid give off little bubbles of gas continuously for a couple of weeks. Spongy lead seems to have very nearly strong enough affinity for the electro-negative radicle of sulphuric acid to combine by evolving hydrogen, more especially if the acid is strong. It seems likely that traces of some metal even slightly negative to lead may start local action. Platinum and lead, for instance, decompose dilute acid at once; but perhaps traces of arsenic or antimony in the oxides from which the reduced coating has been made, or in the acid, may sometimes produce the same result. Peroxide of lead, on the other hand, is more stable, though when heated with strong sulphuric acid it seems to evolve some oxygen and turn lighter in colour.

Electro-gilded copper was attacked at once by sulphuric acid.

(*To be continued.*)

LEGAL INTELLIGENCE.

Edison and Swan United Electric Light Company v. Woodhouse and Rawson.

The Attorney-General resumed his arguments in this case on Friday morning last. He directed the attention of the Court to what constitutes the subject matter of a patent. He submitted that if their lordships held that Edison's claim could not be regarded as subject matter of a patent, they must find that it had been anticipated, and he put it boldly before them, as he had done on the previous day, that nobody could have made

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the patented article from the whole of the knowledge, Swan's included, prior to the date of Edison's specification; and if that were so, they could not come to the conclusion, as a matter of law, that Edison was not fully entitled to his second claim. He said that they could not put so wide a construction upon claim 2 as to bring it within any one of the whole of the anticipations which had been referred to by the other side. Unless he had wholly misconceived the evidence, the case of his clients was not that they desired in any way to narrow the claim in order to support the validity of the patent. Their case was that, to-day, with the existing knowledge if there were put before a competent workman, who did not know of Edison's patent, the whole of the previous instructions, and he were asked to make from those instructions an incandescent electric lamp, he could not do it. The Attorney-General then read the evidence of Dr. Odling in support of this contention, and said that unless the defendants were prepared to throw it overboard, it absolutely destroyed the suggestion that a filament could be obtained from any information given to the world by Pulvermacher, Van Choate, or others, and if their lordships, having regard to the weight and authority of that evidence, given by men of great scientific attainments, said that Edison's specification was not good subject matter of a patent, they would be striking at the root of the law which had protected to their inventors the most useful and ingenious discoveries of the last fifty years. He next referred to the evidence of Dr. Franklin and Sir Frederick Bramwell on the subject of high and low resistance in the conductor, and proceeded to remark that he did not at all say that the object of Edison's patent was simply to obtain high resistance by reducing the cross-section, which could have been achieved by putting in a non-conducting material; but, assuming that people knew how to get the required resistance by cutting down the carbon, they had absolutely failed to get a good lamp. They never got further than Swan, and why did his clients succeed afterwards? Because they made the filament before it was carbonised. The merit of this patent, therefore, was not so much in its reducing the sectional area as in the way in which it was done. He then cited Heywood *v.* Hamilton from the legal decisions in the "Record of British Patents," in which Lords Justices Brett and Bramwell held that a new combination of an old machine producing a new commercial article might be made the subject matter of a patent because that combination, to all intents and purposes, made it a new machine. On that assumption he claimed that Edison's combination was not only new in itself but the carbon filament had not been known before. If the case just quoted could be regarded as a description of a particular machine, *a fortiori* Edison's was a particular description. For the first time a successful incandescent electric lamp containing a carbon filament within the description of filament in the specification and the other three parts which went to make up the combination which Edison claimed, was produced and made a commercial success. The Attorney-General next cited Neilson *v.* Bedwin, in which Lord Westbury held that the nature of the antecedent information to make a subsequent patent invalid must be such that persons of ordinary knowledge of the subject would at once perceive and understand, and be able practically to apply the discovery without the necessity of making further experiments and gaining further information before the invention could be made useful. He then proceeded to say that he did not wish to draw comparisons, but it was absolutely impossible for him with his limited knowledge of scientific discovery to imagine a case in which that doctrine was more remarkably illustrated than the case just referred to. For thirty years people had been striving to make the electric light a success. For the last sixteen years Mr. Swan, Mr. Lane-Fox, and a number of other men had all been as it were leading up to it, and yet they stopped short of the point of success. He would even go further and say that in consequence of that they were absolute failures, and so remarkable was this fact that the witnesses showed that everything, Swan's lamp included (which was undoubtedly the best up to his day), could not have produced Edison's combination. Moreover, there was no particle of evidence which went to show that there was any difference between a patent for a combination and a patent for anything else. If a combination was subject matter for a patent—as undoubtedly had been held by the House of Lords—then prior information of Mr. Edison's combination must be proved to make that patent invalid. It was no good to say, "We can find a vacuum, or a filament, or a carbon pencil used before Mr. Edison's combination." If they were to give proof of the anticipation of that combination they must find an antecedent combination which came within the description given in the specification of the second claim. This doctrine was most pointedly brought out by Lord Cairns in the case of Harrison *v.* The Anderston Foundry Company. In conclusion he submitted, that on the evidence and on the legal authorities he had quoted, that if this invention, which was absolutely a new commercial article, producing extraordinary results, were not to be protected, it would simply wipe out a very large portion of the patent law of this country.

On Saturday morning, in the absence of the Attorney-General, Mr. ASTON, Q.C., resumed the arguments on behalf of the Company, principally directing the attention of the Court to the law of patents bearing upon the case, and quoting a number of judgments, notably those of Otto *v.* Linford and Hill *v.* Evans, in support of the second claim.

Sir HORACE DAVEY, in replying, said that the Attorney-General, and to a certain extent Mr. Aston also, had attached, in his opinion, far too great importance to the fact—which he (Sir Horace) would take to be a fact—that it was proved at the trial that a workman could make a lamp (and a good one, he would admit) from the description in the specification; and the argument used by the Attorney-General was this, "That inasmuch as the sufficiency of the specification has been either proved or admitted (it did not matter which for the purpose of argument), *ergo*, you cannot quarrel with the wideness of the claim." That seemed to him (Sir Horace) to involve a fallacy of language. "Sufficiency of specification" might mean two totally different things. It might mean either that there was a sufficient description in the specification to enable a workman to make a lamp which would be within the claim, or it might mean that there was sufficient description in the body of the specification of that which was claimed of the patentee's invention. He was not prepared to dispute, nor did he desire to dispute, that it was proved at the trial that a workman could, by taking the specification in his hands, make a lamp from the description which would be a lamp within the claiming clause. At the same time, it had been disputed, and Mr. Jamieson gave some evidence about it. But it was never a serious matter of contest whether there was a sufficient description to enable a workman to carbonise ordinary fibrous vegetable matter. A workman could take a strip of bamboo fibre which would be a fibrous vegetable substance within the meaning of the specification, and the description or terms in the specification would be ample to enable him to carbonise that vegetable material, and, having done so, to place it in a lamp for the purpose of a burner. But that was a totally different proposition from what was claimed. What his clients alleged, and, in fact, he did not think he was exaggerating when he said it formed nine-tenths of his argument in the Court below, and which, according to his conception of the case, formed the strongest part of it before their lordships, was this, that assuming the second claim to bear a wider construction than that which had been put upon it by the learned judge, what they denied was that there was any sufficient description of what a filament was to be found within the four corners of the specification. Or in other words, they denied that the patentee had particularly described and ascertained the nature of his instrument as claimed in his claiming clause. The words in the Act were, that the patentee was "to particularly describe and ascertain the nature of his invention." It was in that sense that he submitted to their lordships and made it the foundation of his argument, that the specification was insufficient. Or the argument might be put in another form, that by his claiming clauses the patentee in this case had claimed something which he had not described in his specification if they bore the construction which the Attorney-General put upon them. He (Sir Horace) might be right or wrong as to that, but whether right or wrong, it was not enough to say that a workman by taking a specification in his hand could carbonise a strip of bamboo and put it into a lamp. The specification might describe in the most careful and minute manner a process by which a workman could produce the patented article, but if the claiming clause claimed as the patentee's invention something which was not found within the four corners of the specification then it was not particularly described. It appeared to him (Sir Horace) that the difficulty which his learned friends, with all their experience and ability, and all the thought which they had of course given to the subject, had in putting an intelligible meaning upon those words of the second claim (which was the real subject of dispute) was indicated by the difference of view put forward in their arguments. Mr. Aston's final definition of a carbon filament was this:—"A carbon filament within the second clause means a carbon conductor of small cross-section, of great length, possessing such an amount of flexibility and resilience as will allow of expansion under the influence of heat." The first observation that he (Sir Horace) would make upon this was that it was not necessary that high resistance should enter into a carbon filament, which applied to both his learned friends' arguments and to the claim itself when they came to look at it, because while the first claim spoke of a carbon filament of high resistance the second claim spoke only of a carbon filament, being therefore not confined to high resistance, so that high resistance did not enter into Mr. Aston's definition at all, inasmuch as the resistance depended upon the length as well as the thickness, and such a conductor might be of comparatively low resistance. With regard to flexibility he had already said, and he would now repeat, that it was impossible for his learned friends to find from the beginning to the end of the specification any passage in which flexibility was spoken of as one of the characteristics of a carbon inductor or filament when it was prepared for use in a lamp. It was undoubtedly true that the patentee did speak of flexibility with reference to the filaments, but their lordships would observe that the flexibility was spoken of (and this he would show from the evidence of the scientific witnesses) with reference to a filament, strip, or wire, before it was carbonised, and not after it was carbonised. Indeed, he would go so far as to say that the mind was carried away from the idea of flexibility being an attribute or desirable characteristic of the carbon conductor when formed for the purpose of being put into a lamp, by their being actually told that provision was made for its stiffness and not for its flexibility. [Read specification.] So far from that being a fancy of his own, both Dr. Hopkinson and Mr. Imray pointed out that stiffness and not flexibility was a thing to be aimed at. Mr. Imray said that there was to be sufficient flexibility before, and stiffness after carbonisation. His learned friends had been guilty of some fallacy in speaking of flexibility. What did they mean? There might be flexibility in the sense in which a thread was flexible upon which they could tie a knot. Or they might have flexibility in a cane which might be bent into an arch. Flexibility in that sense was merely a question of degree. The flexibility which was wanted before the carbonisation and the filament had received its shape for the purpose of winding it round a bobbin or winding it into a spiral and maintaining it in that form was a totally different thing from the flexibility to which his learned friends alluded so much in the Court below. They said now something of this kind, "That the flexibility of these burners is a flexibility of quite a different character, and wherever you find flexibility spoken of in the specification it is of the first kind you alluded to, and not of the second kind."

Lord Justice FRY: Putty, I think, was the illustration.

Sir HORACE DAVEY said that was so. He did not say it was any answer to a patentee to say "You did not see all the advantages of your invention." He was not suggesting that. But he did say this, that where an

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expression was used, such as "carbon filament," without any express definition of it, and where the patentee, or those who represented him, gave a definition at the Bar of that, then they must find that definition within the four corners of the specification, or they must find if he had not given them that, a definition with reference to those particular advantages. He made the same remark with regard to "resilience," which was not spoken of there at all. So that he concluded that these two conditions that Mr. Aston laid down, of "possessing such an amount of flexibility and resilience as will admit of expansion under the influence of heat" did not form any part of the definition of a carbon filament as used by Mr. Edison in this patent, so far as that gentleman's meaning could be gathered from the specification. As to cross-section, he asked what amount of cross-section, what length would make the thing a filament? He would merely remind their lordships that the witnesses one and all said that this was merely a matter of degree. They could not draw the line. They had no guide given by Mr. Edison himself, except that it was to be, if one might judge from the words of the specification, of "such smallness of cross-section and comparative length as will give a high resistance of from one to 500 ohms," and the wire which he spoke of was so small as seven-thousandths of an inch. If the carbon filament was to be of "small cross-section and comparative length as will produce high resistance," then he would show their lordships presently that a carbon filament of that definition had been previously described and published. Having referred to Otto *v.* Linford and other cases, he said: If Mr. Edison had confined himself to claiming what his clients contended he did claim, the making of a lamp which contained as one of its constituent elements and as part of the combination, a carbon filament made in a mode pointed out and described with considerable detail in the specification and shown in the figures, then there could have been no objection taken to it. Whether it might or might not be anticipated by an earlier patent he was not now upon, but so far as the claim itself was concerned Mr. Edison would have been in the enjoyment of his patent. But having put in one thing he put in a claim which not only covered what was described, but a great deal more; yet by his greediness—if he might use the expression not in an offensive sense—Mr. Edison had done, what patentees often did by grasping at too much, destroyed the validity of his patent, and that was the point which he (Sir Horace) desired to bring to their lordships' attention on this question, that being the mere matter of degree, and the patentee not having told either in figures, bounds, or any other mode, what it was that he intended to claim, the second claim could not be held to be valid.

On resuming on Monday, Sir HORACE DAVEY proceeded to endeavour to show that the failure of Swan's lamps was due to overcharge of current or bad manipulation rather than to any inherent defect in the lamp itself. Whatever importance was to be attached to the question whether Swan's was or was not a successful lamp, the evidence, when properly understood, did not go to support the contention of his learned friends. And assuming that Edison's patent did not bear the large construction which the Attorney-General claimed for it, but bore a smaller construction, was there or was there not evidence of infringement? He would endeavour to clear the ground upon this subject as far as he could. His learned friends, as far as he understood their arguments, did not raise the question which they did in the Court below, and impressed upon the learned judge that there was evidence that Woodhouse and Rawson's lamp was an infringement of the first claim, or, in other words, they did not now ask their lordships to differ from the learned judge who held that there was no evidence to show that Woodhouse and Rawson's lamp was made as described. It was said, and this was the point which he had to put, that Woodhouse and Rawson's lamps were infringements of Edison's patent—first, because they contained a burner which was of small cross section compared with its length, and had a certain amount of elasticity and resilience. He had already said, and he would repeat, that if that were the true construction of Edison's patent then he must plead guilty, because undoubtedly the burners of Woodhouse and Rawson had a small cross-section in comparison with their length, and they had a certain varying amount of flexibility and resilience. But he had already addressed their lordships for the purpose of showing why that could not be the construction of Edison's patent, and why, if it were the construction of it, the patent was too large or too vague, and did not sufficiently ascertain and describe the nature of the invention. Then it was said they were an infringement of Edison's patent because there was evidence, they said, that the carbon filament or burner in Woodhouse and Rawson's lamp assumed its filament character before it was carbonised. He could only say he was not aware of the evidence upon which they relied for the purpose of showing that, except that Sir Frederick Bramwell said he did not know any other mode by which it could be made. Even Sir Frederick Bramwell said that he was not aware of what was stated to be a secret process. He attached the greatest importance, and he knew their lordships attached the greatest weight, to whatever fell from Sir Frederick Bramwell, but, on the other hand, he was not detracting from the respect they all felt for that gentleman when he ventured to say that he had yet to learn that Sir Frederick Bramwell had the faculty of omniscience. Mr. Aston, in the course of his arguments, seemed to indicate the very mode in which filaments had been or might be made. To put it hypothetically, and only for the purpose of illustration, Mr. Aston seemed to say, "You may get carbons from the decomposition of a hydro-carbon or certain oils on a glass in the form of a sheet, or like gold leaf cut in "strips." His learned friend knew very likely what he was talking about, and he (Sir Horace) called him as a witness in favour of Woodhouse and Rawson to this extent, that because Sir Frederick Bramwell said there was no mode of which he was aware, that was no evidence that no such mode existed.

Lord Justice COTTON: You have suggested that it should not have been assumed that this was made into a filament before it was carbonised. How about the last sentence of Mr. Rawson's evidence?

Sir HORACE DAVEY said he was coming to that. He was not aware of what his learned friends assumed, having no control over the operation of their minds; but he was perfectly certain of this, that if that assumption had been made it was not warranted by anything which fell from either himself, by admission or otherwise, or, according to the best of his knowledge, from his friends Mr. Charles or Mr. Macrory. It was said that Mr. Justice Butt came to the conclusion that it received its filamentary character before it was carbonised. He had read through the learned judge's judgment again, and he could not find anything of the kind. He could not contend that he had read through all the casual observations at the trial, but he did not think that any interlocutory remark could be found to have that effect. The only thing left them was Mr. Rawson's evidence, and he ventured to say that that was an entire misunderstanding as to its meaning. He would go further than that, and say that if his learned friends intended to rely upon this point as against Mr. Rawson, the least they could have done was to have asked Mr. Rawson straight out. They might say they did not desire to pry into Mr. Rawson's secrets. He would give them full credit for their desire to respect the sanctity of Mr. Rawson's manufacture. At the same time it would not have been unduly interfering with Mr. Rawson's secrets, if they intended to rely upon this, to say that was a crucial test of whether there was an infringement or not. They asked Mr. Rawson a great many questions, and they ought to have asked him this question:—Do your carbon conductors assume their filamentary character before they are converted into carbon? The Attorney-General had referred to the final question in Mr. Rawson's evidence, in which there was an ambiguous reference to carbonising, which he (Sir Horace) understood—though he admitted it was ambiguous—and which the learned judge understood, and which was, he thought, understood by everybody in the court. His learned friends were not entitled to draw an inference from an ambiguous reply on a vital question, when it was open to put a direct question which they did not venture to do. [He read the evidence to show that what they were dealing with there was "flashing"—that is to say, that there was a further deposition of carbon after the conductor had assumed its filamentary character, after it had been manufactured, and after the lamp had been made, similar to that described by Sidot and Lane-Fox.] He was entitled to say, in conclusion, that if his learned friends had nothing better to rely upon than this ambiguous expression, in order to fasten a charge of infringement upon Mr. Rawson, then it was their duty to clear up the matter by bringing out what was exactly in Mr. Rawson's mind. They had no affirmative evidence to support them, and they declined the offer that a report should be made by an independent person upon this point. Moreover, Mr. Rawson said that he was willing to make the offer again; and, if their lordships thought that a report should be made, he (Sir Horace) would now repeat the offer on behalf of his clients.

Judgment was reserved.

COMPANIES' MEETINGS.

The Gulcher Electric Light and Power Company (Limited).

The fifth ordinary general meeting of the shareholders of this Company was held at Cannon-street Hotel, on the 20th inst., under the presidency of Mr. Daniel de Castro.

The SECRETARY read the minutes of the last meeting, and afterwards read the notice convening the present meeting.

The CHAIRMAN stated that the notice just read was ordinarily printed on the back of the annual report, but he was sorry they had not been able to do so this time. They were interrupted in the middle of the audit by an order to take their books to the Court of Appeal on the hearing of Mr. Gilman's appeal against Mr. Justice Grantham's judgment in favour of the Company, an appeal which was dismissed with costs. The audit, however, through the books being at the Court, had been postponed for a week, and consequently many of the shareholders might only have received the report and accounts that morning instead of a week ago, as had been customary.

A SHAREHOLDER said it would have been better to delay calling the meeting.

The CHAIRMAN said he quite felt the force of any shareholder objecting that he had not had time to consider the report, and he would be quite willing to adjourn the meeting if the shareholders desired that course should be adopted.

Mr. A. J. KING said he thought that if the Chairman proceeded with his address the shareholders would obtain all the information they required.

The CHAIRMAN, in the course of his remarks, said: As no adjournment is moved I think, having regard to the shortness of time you have had to consider the report, that it would be well if I read a part of it. It says:—It will be observed that the accounts of the past year are presented in a somewhat unusual form. Those for the nine months ending June 30th, 1886, are believed to be absolutely accurate. They are absolutely correct, and have been signed by the auditors. Those for the 12 months ending September 30th can only be approximately correct. The reason for this apparent irregularity is that the Directors resolved to alter the period for holding the annual general meeting, and to make the Company's financial year end in future on June 30th. The advantage to be gained by this change is that the annual stocktaking (which is a very laborious and lengthy process, involving among other hindrances to business the closing of the works for at least a week) will in future take place in July, when

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the electric lighting business is slackest, instead of in October, which is one of the busiest, if not the busiest month in the year. In accordance with this decision, stock was taken last July. The accounts up to June are absolutely correct, but between June and September they are only approximate accounts, for we have not the accounts based upon the second stock taking. Mr. Mountain, our manager, has very carefully examined into the outgoings and incomings, and has estimated his stock as nearly as possible. Those shareholders who had preserved the reports and balance-sheets yearly would be able to satisfy themselves as to the progress of the Company, and on page 3 of the report your attention is drawn to a few facts which I think deserve your consideration. I have there begun by comparing the position of the Company as far as its liabilities are concerned. On the 30th June, 1883, when we took over the Company, the share capital of the Company consisted of 47,747 shares, of which no less than 19,660 had been issued to vendors as fully paid up. On the 30th June, 1886, the total share capital of the Company consisted of 20,097 shares (since reduced to 19,633 shares), of which 5,964 only are vendors' paid up shares. Of these 5,964 shares Messrs. Fox, Johnson and Garrett, the vendors to the Company, are under covenant to surrender 1,374, and if we are successful in the action pending to compel the surrender of these shares, there will be rather less than 4,600 vendors' shares with which the Company will be burdened. On the 30th June, 1883, the other liabilities of the Company were admitted by the Board to be £19,313. On the 30th June, 1886, they were only £7,265. The liabilities have therefore been enormously reduced in each direction, On the other side of the balance-sheet the plant and stock on June 30th, 1883, was alleged to be of the value of £20,000. You will remember very well the discussion that took place at the first general meeting, at which it was admitted that that was the only the roughest estimate, and afterwards that £20,000 was found to be so far in excess of the value of the stock that in a subsequent year we wrote off £2,000. The value was really nothing like £20,000, it was nearer £12,000. The trade accounts due to the Company at the 30th June, 1883, were £1,106, and the cash at the bank was £2,560 (the Directors having just then made a call). On the 30th of June, 1886, plant and stock stood at £31,251, which has been most carefully valued; the trade accounts due to the Company at £1,900, and the cash at the bank at £97. Every one of the assets has considerably increased. Referring to the manufacturing and trading accounts for the 14 months ended 30th June, 1883, the total works expenditure was £24,000, of which £2,876 was charged for superintendence. The result of this expenditure of £24,000 was sales amounting to £5,600, and the admitted manufacturing loss on the 14 months in question was £6,874. For the nine months ended 30th June, 1886, the total works expenditure was £13,000 (very little more than half the works expenditure before; and on the opposite side of the account, in the nine months, we have sold £11,500, just double what was sold before, and there was a net manufacturing profit of £828, against an admitted loss of nearly £7,000 for 1883. In this department also, in which the sales, &c., have been raised from an average of £400 per month to an average of nearly of £1,300 per month, and where a manufacturing loss of nearly £500 per month has been converted into a manufacturing profit of nearly £100 per month, the Directors desire to add that the improvements have also been most steady and continuous. This is not an accidentally favourable balance-sheet that we are comparing with the original balance, but one that has grown from a terribly bad position into the present hopeful one. Coming to the profit and loss account for the fourteen months ended June, 1883, the total head office expenses were £4,724, including £1,750 which was paid for Directors' fees, and £782 for law charges, the deficit for that period being £18,578. For the nine months ended June 30th, 1886, the total head office expenditure was £2,130, while the deficit for the nine months has been reduced to £1,268. The above figures also speak sufficiently for themselves, but as there is even yet a balance to be carried to debit on this account the Directors desire to compare it with the same account as presented in 1885; and whereas in 1885 the head office expenses amounted to rather more than £360 per month, the same expenses for the nine months ending June 30th, 1886, were somewhat less than £240. On the other hand, whereas in 1885 only £121. 14s. 6d., or about £10 per month, was carried to the credit of this account, £862. 17s. 11d., or upwards of £90 per month, has been carried to its credit for the nine months ended June, 1886. So that, while the head office expenses have been reduced during the last nine months by one-third, the trading profit has increased ninefold. This is a comparison with even last year's accounts. Last year I told you that I saw no reason why our head office expenses should not be reduced ultimately to £2,500 a year; and I am glad to say that this year, notwithstanding very heavy law charges, they have been reduced to £2,600. These economies are being extended in every direction at the works, while the trading increase is being maintained. Not only has it been maintained during the three months from June to September last, but I may tell you that it has been much more than maintained since September—it has been very largely increased. I referred to a deficit of £1,268 on the profit and loss account for the nine months to June last, but more than half of that is due to law charges, which, however, heavy as they were, were only half of what they were last year. We have reason to believe now that there is an end of the litigation which commenced three years ago with our promoters—the original Directors. On the whole, we have succeeded very well in recovering from the old Directors by a compromise and arrangement a very large proportion of that which they claimed. Mr. Blundell, on the other hand, insisted on his strict legal rights, and these he obtained in a court of law. Our case was never heard, for our junior counsel was not there, and our leading counsel required his assistance. But for that I am very confident that even Mr. Blundell, our late chairman, would not have maintained his claim. I am sure you would not wish the litigation prolonged by referring the matter to the Court of Appeal. There is an account dealing with the Gülcher patents, the Crookes patents, Mr. Blundell's disputed fee, and certain bad debts. Those items are all placed below the line in the profit and loss account, because they are debits which are not attributable to the business of the last nine months. With reference to the Gülcher dynamo, I hope the shareholders will approve of the course which the Directors have taken. What we have tried to do is to avoid shams, whatever else we do. The price paid for our patents was infinitely more than they were worth if they were ever patents at all, and last year it became necessary for us to consider whether we would continue the Gülcher dynamo patent in existence. We came to the conclusion that we would not, that if it were an English patent at all it was for a machine that was now quite obsolete. We therefore decided not to maintain the patent, and we have therefore let it lapse and have written off what we consider the price at which it has been estimated. There stood in our balance-sheet the sum of about £22,000 still due for the Gülcher patents. They were all bought in one sum for £100,000, and there was no division, no allocation of so much to lamps, so much to dynamos, &c., but we had to settle what we would write off for the dynamo, and the fair and business way was to ascertain what might be the fair value of the lamp patents. The lamp patents are good for an excellent lamp which has held its own in the market. We have written them down as worth £2,000, treating the dynamo patents and all that was paid for them as the balance. That involved our writing off £20,000. As a matter of fact, we are no richer or poorer for that. It is a mere matter of account, and it will perhaps enable us to know more where we are. If we had maintained the patent, we, in common sense, ought to have insisted upon enforcing it, and we should have had to bring actions against two or three of the most important companies for infringing what was possibly once a patent, but if so, it was so very slight, that I do not believe we should have succeeded in getting any damages at all. The next item written down below the line is in reference to the Crookes lamp. As a matter of fact we are continuing even now to have a few of the Crookes lamps returned on our hands, with plaintive appeals to allow something for them. However, as to the £400 which we refer to in the report, we felt that we were bound to credit our New Zealand agents with that amount. They have in their hands £7,000 worth of these lamps, which had been sold to them at very high prices, but which they had never been able to do anything with. We are using up those lamps in our shops, and we find the complaints made about them by our agents is true. Directly one is put up it may go out, while another which is put up may last a week. We do not know how long they may last. Mr. Blundell's disputed fee account I need not refer to further. We settled with all the former Directors on very advantageous terms. The item of £638 which is also below the line represents several debts due from various companies and customers, some of which have been standing as assets almost from the commencement of the Company, and all of which are bills of doubtful value. Having given the detailed particulars as to the items comprising the total amounts, he continued: What I wish you to see is that this £638 does not mean any large number of bad debts which have been incurred by us. Having referred to various other items in connection with the annual manufacturing accounts for the year 1883 to further emphasise what he had already pointed out to show the gradual improvement in the position of the Company, he proceeded: The shareholders will thus see that there have been a gradual and steady decrease in the liabilities, and a steady and gradual increase in those items which indicate profit. Since we last met we have issued £5,000 of debentures, which you gave us power to issue. You will remember that last year we had no power to issue debentures because our capital was called up. We obtained the permission of the shareholders, and we applied to you then for the money. We found our wealthy shareholders would not part with their money, and we had the greatest difficulty in getting this £5,000 from the shareholders. Up to the present we have had the portion of this money which has been subscribed by the shareholders from those who have stuck to us from the first. From those gentlemen we have succeeded in getting £3,000, and the other £2,000 has been subscribed by your Board. I do not take any credit for having subscribed that amount in conjunction with the other Directors, although I am your largest debenture holder. I mention it as a matter of encouragement, because I think it shows that those who know best about the position of the Company have the most confidence in investing their money in it, and for that reason we have not hesitated as a Board to take up this £2,000. We are now going to do business. We are not going to drag along as we have been doing. Though there is a deficit, still we have done with deficits, and we are going to do business, and to do business we must have more money at our command. We do not want at present very much, but we have taken power as a Board to issue £20,000 of 7 per cent. debentures, and we have explained to you in the report how we propose to deal with that. We propose to keep £15,000 for the purpose of issuing it as we require to do so. If we get a very heavy order (and we have two or three in view), which our working capital is altogether inadequate to carry out, we should invite you to subscribe so much towards that particular order. These debentures will only be a second mortgage at present, because the £5,000 of mortgage debentures which we have already issued must remain a first mortgage. Of this second issue, however, £5,000 will be reserved for paying off the £5,000 of the first issue when it becomes due, so that before the year and a half now remaining for the first mortgage debentures to run off this proposed issue of £20,000, will spring into a first charge. He then referred with regret to the retirement of the late secretary (Mr. Russell Day), and spoke in approving terms of the services which that gentleman had rendered to the Company. Continuing, he said: You know the business of this Company has been practically carried on by what is called a "Works Committee," which consists of Mr. Mountain, our manager, Mr. Fricker, our electrician, and myself, who act as a sort of mediator or looker-on. We owe a great deal to both those gentlemen for the position in which

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you are. You would not be where you are had it not been for Mr. Mountain and his exertions, which have been almost superhuman. It is to him mainly that you owe the fact that the Company has been got into the position in which it now stands. I hope some one will second the vote, which I intend to propose, of 50 guineas to that gentleman, as an honorarium. We have elected two new Directors, who will really, I hope, assist us very materially. We have not been a very powerful Board—certainly not very much known in the world, and we have not represented any very large and powerful people. Mr. Grëwing, of the firm of S. Oppenheim and Company, has consented to come on to the Board and assist us in every way he can, and the assistance of such a firm will be very material. Mr. Thomas Lloyd, who has also a very considerable interest in the electrical world, has come to a like conclusion with Mr. Grëwing, and has also joined us. Each of these gentlemen started by taking £250 debentures merely as a kind of earnest that they mean business. Mr. Grëwing is chairman of the Austrian Company, besides being a Director of one or two telephones companies, and Mr. Lloyd is a director of the River Plate Telephone Company. In the ordinary course I believe it is customary for them to resign together with the other retiring Directors, who are Major Cotton and Mr. Wallace. The Auditors, Messrs. Wm. Edwards, Jackson and Co. (to the value of whose services he testified) also retire, and offer themselves for re-election.

Mr. Murray asked what the Directors proposed to do with the deficit of £71,000 in the balance-sheet.

The Chairman: That loss of £71,000 is a loss which we shall never get over. We have discussed this question at our former meetings more than once, and when we get the shares from Messrs. Fox, Johnson, and Garrett, for which we are suing them, we propose to bring a scheme before you of reducing our capital down to the present value of the shares. That is to say there is now something like £32,000 or £33,000 which we consider absolute assets in stock plant, patents, money, and consignments. If you take away from that the trade debts, there remains a surplus of £25,000 or £26,000, and we propose to reduce our £100,000 capital by three-fourths, down to £25,000, and then we shall be in a position to declare a dividend out of any profit we earn. At present, if we earn a profit next September (and I hope we shall), that must be carried to the reduction of this loss, and unless we make the reduction of the amount mentioned, no possibility of dividends can be looked for in our life time. If, however, we carry out that proposition, I see no reason why this Company should not be a dividend-paying concern in the course of the next two or three years. There is a further idea that I have ventilated, I think, in this Company. My idea is that we might then increase our capital to £50,000 by making those shares which have been issued one-half paid up, but that could only be done with the consent of the shareholders. By that means we should be able to raise our debentures at 5 per cent. instead of 7 per cent., because there would be the security of the unpaid capital as well as the security which constitutes the security of the debentures at present. Of course there is the extra liability, and some shareholders might shy at that, but I think if we carried out that proposal we should get a quotation on the Stock Exchange, and in that case those shareholders who shy at the liability might easily get rid of their shares on the Stock Exchange at their full value. This matter will be brought before you again before the end of the current Gülcher year, and those who have heard what I have said on the subject now may think between now and then of some modification that may be an improvement on my idea.

Mr. King thought that the Chairman's statement, showing the progress of the Company, could not be other than satisfactory to the shareholders. It was, of course, very unsatisfactory to find that the capital required to be written down to the extent of 75 per cent.; but they must all recognise that this heavy writing off was not in the least degree to be referred to the want of skill or attention on the part of the present Directors, but to the hallucination which existed three years ago with regard to electric lighting, when fabulous sums were given for all sorts of patents which in the end proved to be worthless. The Chairman, with his characteristic straightforwardness had told the shareholders the worst, and he (Mr. King) thought they were all now resigned to the fact that the proposal mentioned by the Chairman for reducing the capital was necessary. He had no doubt, however, that the shareholders would take upon themselves the liability to which the Chairman had further alluded for the sake of improving the position of the Company. Those who might not be inclined to face the liability would at all events have a market to see what their shares were worth. He thought that the Board and the shareholders were to be much congratulated on the accession of able and influential men to the Board.

The Chairman then moved the adoption of the report and accounts.

Mr. Lloyd seconded the motion, which was carried unanimously.

A hearty vote of thanks having been accorded to Mr. Russell Day,

The Chairman proposed a resolution awarding 50 guineas to Mr. Mountain for his labours as managing director.

A Shareholder seconded the motion, which was carried unanimously.

Mr. W. C. Mountain in reply expressed his belief that if they continued to pull together they would ultimetely make the success of the Company.

Resolutions were then passed re-electing the Directors and Auditors.

Mr. King afterwards proposed a vote of thanks to the Directors for their successful conduct of the Company's affairs. They had a most admirable Chairman, and if man's energy could rescue a moribund company, Mr. de Castro had given evidence of his capacity and energy. He fully expected to see the day when the Company would be paying satisfactory dividends.

Mr. Woodly seconded the motion, which was agreed to *nem. con.*

The Chairman acknowledged the compliment, and the proceedings terminated.

The New Telephone Company.

The annual meeting of this Company was held on Saturday last. We shall give the detailed report in our next issue.

NEW COMPANY.

The Taunton Electric Lighting Company (Limited) was registered on the 16th inst. by H. F. Kite, 11, Queen Victoria-street, E.C., with a capital of £10,000, divided into 2,000 shares of £5 each. The object of the Company is to carry on as a going concern a business hitherto conducted by Henry George Massingham, at Taunton. The Company is registered without Articles of Association, and the regulations of Table A in the Act of 1862 apply.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Dec. 22.		Business Done Week Ending Dec. 22. Highest.	Lowest.
Anglo-American	36,	37	36½	36
Do. Preferred	59,	60	60	59
Do. Deferred	13½,	14½	14	—
Brazilian Submarine	10⅞,	11⅛	11⅛	10 13-16
Cuba	10⅞,	11⅛	11 3-16	11 1-16
Do. Preference	18,	19	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Preference	9½,	10½	—	—
Direct United States Cable	8¾,	9¼	9	—
Eastern Telegraph	10⅛,	10⅝	10⅜	10¼
Do. 6 per Cent. Preference	13½,	14	14	—
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	10½,	10⅞	10 11-16	10⅝
German Union	9¼,	9¾	9	—
Globe Telegraph and Trust	5⅛,	5⅜	5⅜	5¼
Do. Preference	12⅛,	12⅝	12⅝	12¼
Great Northern	13⅜,	13⅝	13⅝	—
Indo-European	34,	35	—	—
Reuter's	7,	7½	—	—
Submarine	190,	200	—	—
West India and Panama	⅞,	1	⅞	⅞
Do. 1st Preference	8¾,	9¼	—	—
Western Brazilian	7,	7½	7 5-16	—
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Companies.	Closing Prices. Dec. 22.		Highest.	Lowest.
Consolid. Telephone and Maintenance	⅛,	⅜	—	—
Oriental	3-16	5-16	—	—
United Telephone	13,	13½	13 13-16	13⅝

ELECTRIC LIGHT.

Companies.	Closing Prices. Dec. 22.		Highest.	Lowest.
Anglo-American Brush Light (£3 paid)	2½,	3	2⅝	—
Do. (fully paid)	4¼,	4¾	4¼	—
Swan	1⅛,	2	1⅝	1 9-16
Maxim Weston	5-16,	7-16	5-16	—

MISCELLANEOUS.

Companies.	Closing Prices. Dec. 22.		Highest.	Lowest.
Telegraph Construction	39	40	39¾	39½
India Rubber, Gutta Percha, and Telegraph Works	24	25	24¾	24½

TRAFFIC RECEIPTS FOR NOVEMBER, 1886

Companies.	Nov., 1886.	Nov., 1885.	Increase.	Decrease.
Cuba Submarine	2,550	2,313	237	—
Direct Spanish Telegraph	1,860	2,032	—	172
Eastern Extension	36,729	40,427	—	3,698
Eastern Telegraph	50,817	56,245	—	5,428
Great Northern	21,200	—	—	—
West Coast of America	4,190	—	—	—

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NOTES.

AMSTERDAM.—Messrs. Siemens and Halske, of Berlin, are about to establish a central lighting station in Amsterdam.

REPAIR OF AN ATLANTIC CABLE.—One of the Atlantic cables which has been broken for six weeks past off Land's End has just been repaired.

RIO DE JANEIRO.—Arrangements have been concluded by the Tramway Company of this city to give the Julien system of electric traction a trial.

REMOVAL.—Messrs. H. and E. J. Dale inform us that they have removed their warehouse for electrical fittings from 4, Little Britain. Their show rooms and offices are now at 26, Ludgate-hill, and their factory at 9, Kirby-street, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending December 24th, 1886, were £3,420, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

LONG DISTANCE TELEPHONY IN FRANCE.—The town of Lille is now in telephonic communication with the five following places:—Roubaix, Tourcoing, Armentieres, Dunkerque, and Bergues. It is proposed to erect a telephone line between Paris and Havre.

ACCUMULATORS.—The Electrical Power Storage Company inform us that during the last 50 days they have received and executed orders for accumulators sufficient to supply 5,150 sixteen candle-power lamps, and having a capacity equal to 3,390,000 watt-hours, or 4,543 horse-power hours.

TENDERS ASKED FOR TELEGRAPH MATERIAL.—The Bombay, Baroda, and Central India Railway Company ask for tenders for the supply of telegraph materials. Forms of tenders can be obtained on application and payment of 5s. to Mr. T. W. Wood, 54, Finsbury-circus, E.C., and must be returned by noon on January 10th.

SECONDARY BATTERIES IN THE UNITED STATES.—The Electrical Accumulator Company, of New York, has erected a large factory at Newark, N.J. This company manufactures cells on the patents owned by the Electrical Power Storage Company in this country, and is said to be backed up by powerful financial support.

PHILADELPHIA.—The city of Philadelphia does not as yet possess a central station for the domestic supply of incandescent light, although it is reported that such an undertaking will shortly be commenced. Only some three or four isolated incandescent plants at present exist in this city, while the number of arc lights exceeds 2,000.

NICKEL-PLATÉD COOKING VESSELS.—An order has been issued in Lower Austria forbidding manufacturers and tradesmen to sell nickel-plated cooking vessels. It is stated that vinegar and other acid substances dissolve nickel; and that this, in portions of one-seventh of a grain, causes vomiting, and is even more poisonous than copper.

THE AMERICAN ELECTRIC LIGHT COMPANY.—This company, which is one of the largest manufacturers of arc lighting apparatus in the States, is endeavouring to obtain a footing in Europe, and has recently concluded an arrangement whereby the firm of Wockaty and Company, of Gothenburg, become its representatives for Norway and Sweden.

PROPOSED UNDERGROUND TRAM LINE.—A scheme is to be brought forward during the next Session of Parliament for the construction of a railway or underground tramway, commencing by a junction with the already authorised City of London and Southwark Subway at Newington Butts, passing under Kennington Park-road and Clapham-road, and terminating near the junction of Stockwell-road with Clapham-road.

NEW TECHNICAL COLLEGE.—At a meeting held at Dundee on Monday afternoon it was agreed to erect a Technical Institute near University College, to be worked in connection with the college. The new building is to be known as the Baxter Technical Institute, the late Sir David Baxter, Bart., of Kilmaron, having left £20,000 for its erection, with a view to the improvement of working men in scientific knowledge.

TEMPORARY LIGHTING.—At the annual Christmas dramatic entertainment, given by the scholars of the Middle Class Schools, Cowper-street, E.C., on the evenings of 20th, 21st, and 22nd inst., the stage was lighted by Woodhouse and Rawson incandescent lamps, the current being derived from E.P.S. accumulators, which were charged in the daytime from the Finsbury Technical College, the two buildings being adjacent.

ROYAL INSTITUTION.—On Friday, January 21st, Sir William Thomson will lecture on "The Probable Origin, the Total Amount, and the Possible Duration of the Sun's Heat." The Christmas lectures commenced on Tuesday, December 28th, and are by Prof. Dewar on "The Chemistry of Light and Photography." On Thursday, January 20, and the following Thursdays, January 27, February 3, 10, and 17, Prof. A. W. Rücker will give five lectures on "Molecular Forces." Other courses of lectures will be given by Prof. A. Gamgee, Edmund Gosse, Prof. Max Müller, Carl Armbruster, and the Right Hon. Lord Rayleigh.

THE WATER POWER OF NIAGARA.—It is stated that a project is on foot for utilising in various ways the water-power of Niagara Falls, the undertaking having been taken in hand by "The Niagara Hydraulic Tunnel and Power Company." Among the objects contemplated is that of converting the waste power into electricity. The report on this gigantic enterprise says that the problem of transmitting the power from Niagara Falls to distant points is also nearing a solution. It is now conceded by practical electricians that it would be entirely practicable to light the city of Buffalo, twenty miles away, with power furnished by the Falls.

STENO-TELEGRAPHY.—It is announced that after many years of labour M. Cassagne has at length succeeded in bringing to perfection his system of steno (or short-hand) telegraphy. We fear, however, that while the apparatus of M. Cassagne has been slowly maturing, other systems—or at least one other system—already outstrips it in rapidity of transmission, and it is difficult to see that any advantage, other than that of speed, could be claimed for such a system. The speed attained by M. Cassagne's apparatus is said to be 240 words per minute ("*une prodigieuse rapidité*"). But it is well known the English Post Office now attains nearly double this speed with the Wheatstone transmitter.

WORKSHOP ILLUMINATION.—We learn from *Industries* that Herr Cohn, of Breslau, in an address to the members of the Naturalists' Association, at Berlin, made an interesting statement concerning the lighting of workshops. He has found, as the result of a long series of observations and experiments, that no working place is to be deemed well lighted by artificial means that has not a minimum illumination of 10 mètre candles. By mètre candle he understands the degree of illumination to be found upon a small disc of paper set one mètre distant from a standard candle light. With less than this, he

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says, the workman's efficiency is diminished, and, in course of time, his sight is seriously weakened.

BELGRADE IMPROVEMENTS.—It is stated officially that a despatch has been received from the British Minister at Belgrade, to the effect that the Municipal Council of that city has determined to undertake some extensive operations for the improvement of the city; amongst others the lighting of the streets is to be reorganised. Concessions for this and other projects will be granted to the lowest bidder, and are open for public competition until the 10th (22nd) March, 1887. Competitors will have to prepare their own form of contract. The population of Belgrade is about 41,000. Survey plans have recently been completed, and can, it is stated, be obtained from the Mayor of Belgrade for the sum of 20fr.

INGENIOUS APPLICATION OF ELECTRICITY.—We recently mentioned the fact that electric temperature indicators were very extensively employed in the vineyards of California, for the purpose of giving warning when the temperature falls dangerously near the freezing point. Bonfires are always kept ready stacked, and they have to be lit at any hour of the night when the alarm is given. In order to save the farmers from the necessity of performing this unpleasant duty *in propriâ personâ*, many of the vineyards in the neighbourhood of San Francisco are provided with an additional arrangement whereby the bonfires are automatically lighted on the fall of temperature. This is effected by placing a little gun cotton in the centre of each bonfire, and providing a firing circuit which is closed by a relay placed in the thermometer circuit.

CENTRAL STATION AT ANGERS.—The following conditions of subscription have been adopted by the company which is running a central lighting station at Angers:—The cost of wiring and the supply of plain brackets is undertaken by the company, who will, however, employ the existing gas fittings wherever practicable. Ornamental fixtures are supplied at the charge of the subscriber. The company also undertakes the entire maintenance of the installation, including the replacement of worn-out lamps, but lamps broken by accident are charged to the subscriber. Contracts are made for a term of five years only; the subscriber pays a fixed annual charge amounting to 12fr. per lamp per annum, and also a sum per lamp-hour, as follows:—4 centimes per lamp-hour for each 10 candle-power lamp; 7 centimes per lamp-hour for each 16 candle-power lamp. Arc lamps, or incandescent lamps of more than 16 candle-power, are charged for by special agreement.

ELECTRICAL PHENOMENON.—Under this heading the following letter appears in *Nature*, December 23rd, from Mr. Thomas Higgin:—"I beg to enclose extract from a letter just received from a young friend at Yloilo, and shall be glad if you will insert it in your next issue. Some of your readers may have further information respecting this interesting sight: 'Yloilo, Oct. 1, 1886. Last night a most extraordinary phenomenon was visible in the heavens. About nine o'clock the sky was perfectly clear, all the stars visible, but no moon, when suddenly the whole heavens were lit up as if by electric light, a very large globe of fire became visible (about the size the moon appears when full) and floated slowly northwards. I was in rather a bad position for seeing where it actually went, a house being between me and the horizon. This ball was followed by smaller ones, which were close to the big one, and gradually got smaller, till they appeared like falling stars, only they went much more slowly.'"

THE ELECTRIC LIGHTING OF MEN-OF-WAR.—The success of electric lighting on shipboard has long been placed beyond all possibility of doubt or question; indeed, on all large vessels either of the navy or the mercantile marine the electric light is now regarded as an essential part of their equipment. It would, however, be a mistake to conclude that nothing remains to be done in the way of effecting improvements in the general system, and we conceive that we are doing the greatest service both to the scientific and the naval profession by indicating any points of weakness, especially when, as probably in the matter we are now referring to, the defect may be remedied without much difficulty. If our information be correct, there are certain ships of the Navy on board which the firing of the heavy guns is usually accompanied by the extinction of the light. It is true that just at present heavy guns are not as a rule fired for fear they should burst, but it is none the less necessary that all parts and fittings should be of sufficiently solid design to withstand the heavy shocks to which a ship-of-war is necessarily exposed.

THE STUDY OF THUNDERSTORMS.—There still remains an immense amount of patient work to be done in the way of protracted and careful observation before the phenomena of thunderstorms can receive anything like complete elucidation. Dr. Hann, of Vienna, has recently contributed a valuable monograph upon this subject. From a study of thirty-two years' observation of thunderstorms in the Vienna region Dr. Hann finds that there is a double maximum of frequency. The greatest number occur in the first half of June, the second smaller maximum is in the end of July; between these is a secondary minimum. (Thunderstorms hardly ever occur in winter.) This agrees with observations in Munich. In Brussels most thunderstorms occur in the second halves of June and July. The daily period in Vienna shows a chief maximum about 3:20 p.m., and a secondary one at 1:20 a.m. The spring and summer storms come mostly from the east and south-east, and seem to belong to Mediterranean depressions, coming up from the Adriatic, as those of late summer seem to be on the south or south-east border of Atlantic depressions.

A NEW ARC LAMP-POST.—In designing an arc lamp-post for street lighting, it is desirable to endeavour to combine economy with maximum height and strength, and also, if possible, to arrange for the replacement of carbons, adjustment, cleaning, &c., to be performed from the street level. If we were also expressly desired to leave out of view the most elementary considerations as to sightliness, we might further take into account the fact that the street would be much better illuminated if the lamp was suspended over the centre of the roadway. We should then very probably arrive at a form of post very similar to that recently introduced by one of the American electric light companies. This consists of an upright post bearing a horizontal cross bar pivoted at its upper part. The longer arm of the cross bar projects over the centre of the roadway and carries the lamp, the shorter arm is provided with a counterpoise. By means of a lever attached to this arm the cross bar can be tilted until the lamp reaches the level of the ground. No mere verbal description can do justice to the hideousness of the design.

OPPOSITION TO THE BELL COMPANY IN AMERICA.—It is stated that a powerful syndicate is about to be formed, in order to endeavour to break down the telephone monopoly in the States, by the introduction of an instrument invented by Messrs. Dann and Lapp, which is alleged to work by make-and-break, and not by alternating currents. It is proposed to commence operations at Rochester, where, as we recently mentioned, a feud exists between the local Bell Company and their clients, and has resulted in the withdrawal of 600 out of 700 subscriptions. Meanwhile we learn that Rochester merchants placard their telephones with sarcastic mottoes, and

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the local telegraph companies find it necessary to double their staffs. With regard to the theory of a make-and-break telephone, it is obvious that unless special care is taken to avoid all self-induction in the circuit, however abrupt the make-and-break may be in the transmitter, the current in the receiver will still be of an undulatory character. We trust, however, that this observation will not have any influence upon the decision of the law courts, to which an appeal will undoubtedly be made directly the new company commences active operations.

OFFICIAL REPORT OF THE VIENNA EXHIBITION.—The official record of the tests of the electrical section of the Vienna International Exhibition of 1883 has just made its appearance in the form of a bulky octavo volume. The tests themselves were of an almost exhaustive character, and undoubtedly reached a very high standard of accuracy; it is therefore the more to be regretted that the delay of nearly three years in their publication should deprive them of almost every interest, save that of a historical character. From the latter point of view, it is, however, of considerable value to have such excellent authority for the statement that in 1883 the highest commercial efficiency yet attained in the construction of dynamos did not exceed 78 per cent., while in quite the majority of machines tested it ranged between 50 and 65 per cent. The tests recorded in the volume comprise a very wide field of investigation, including measurements of power obtained from various engines, the calibration of mechanical dynamometers, tests of glow and arc lamps, accumulators, efficiency of dynamos, primary batteries, thermopiles, conductors, and the transmission of energy. It is a pity that a good index has not been added, which would have much enhanced its value as a work of reference.

PROPOSED ELECTRIC TRANSMISSION OF POWER IN CEYLON.—The *Indian Engineer* states that the application of water power in the planting districts is attracting much attention in Ceylon, where the electric transmission of power for tea factories is likely in future to have an extensive field. It appears that some local tramway company is anxious to obtain information upon the subject, but our contemporary does not mention the locality. In other parts of India the advantages of electric transmission are being canvassed with much interest, and at Bombay the local journals are seriously discussing the possibility of utilising tidal power for the charge of accumulators. We should be sorry to say anything to discourage the idea of utilising the forces of nature to their fullest possible extent, especially in such a country as India. As the *Bombay Gazette* puts it, "With coal at 11s. a ton, as in England, steam may be justifiable, but when coal has to be brought thousands of miles at an enormous expense, it is time that the scientific imaginations of our citizens were set at work to see if a cheaper substitute cannot be got for it." At the same time it is as well to remember that it has never as yet been found practicable to employ tidal force with any economical advantage. On the other hand, the water courses of India will in many districts afford magnificent opportunities for the electric transmission of power.

TONQUIN.—NATIVE IMPROVEMENTS IN TELEGRAPHY.—An extract from a private letter received from a lieutenant in the French Army of Occupation in Tonquin gives an amusing account of the difficulties which have to be encountered in the maintenance of the telegraph lines in that country. On one occasion communication between Hanoi and Haiphong was totally interrupted, and several days elapsed before the locality of the fault could be detected. At length, after traversing the whole length of the line without discovering the fault, the officer in charge observed upon his way back that in the neighbourhood of one of the villages of a friendly tribe the line seemed rather thicker than elsewhere, and on a closer inspection it was discovered that several miles of wire had been removed, and had been carefully and neatly replaced with bamboo rope. The headman of the village explained that iron wire was a valuable commodity in his district, but that as a proof of his affection for the French he had issued the most stringent orders that whenever any wire was removed from the line, repairs were immediately to be effected in the manner described. The officer attempted to explain the difference between conductors and non-conductors of electricity, but eventually found it more to the purpose to intimate that any future supplies of bamboo rope for telegraphic purposes would be utilised for the summary execution of the nearest head man.

CENTRAL STATION LIGHTING AT ROME.—The *Bulletin Internationale de L'Electricité* contains a long account of the central lighting station at Rome which has been established by the Anglo-Roman Gas Company, and is worked with alternating currents and Gaulard-Gibbs transformers connected in parallel. The installation at present comprises 24 arcs of 800 candles for street lighting, and 600 Edison lamps of 16 candle-power, of which the greater number are distributed in three or four large buildings. The name of the makers of the alternating machines is not given, but from some of the details they would appear to be Ganz dynamos. There are two machines, each giving 2,000 volts and 42 amperes. The speed is not given, but the engine from which they are driven is said to run at 250 revolutions and to work up to 150 horse-power. Only one of the dynamos is at present in use, the other being held in reserve. The conductors are placed underground, their total length being nearly four miles. The fittings have been paid for in each case by the consumers, and the charge for current is made at the rate of 80 centimes per hour for each arc, and 8 centimes per hour for each incandescent lamp. A very large extension of the installation is projected, and was in fact provided for in the erection of the buildings where the engines and machines are placed. If the present scheme is carried out the installation will become one of the most important in Europe, and will have a capacity of over 18,000 glow lamps. It is proposed to employ four large machines each capable of supplying 4,000 lamps, and two smaller machines with a capacity of 1,000 lamps, together with three continuous current dynamos for exciting the fields. The total motive power to be provided, including spare engines, will exceed 2,500 horse-power.

MR. BROWN ON THE SEAT OF ELECTROMOTIVE FORCE.—In a paper recently read before the Royal Society on "A Theory of Voltaic Action," Mr. J. Brown expressed the opinion that the difference of potential near two metals in contact is due to the chemical action of a film of condensed vapour or gas on their surfaces. Such a pair of metals is thus similar to a galvanic cell with its electrolyte divided by a diaphragm of air or other gas, and it is the difference of potential of the films that is measured in "contact" experiments; the metals themselves being at one potential. But it appears that covering the metals with varnish, or immersing them in naphtha to protect them from atmospheric action, reduced the difference of potential near them considerably, but not to zero. Drying the atmosphere about a copper-zinc pair by means of phosphoric anhydride in one instance reduced the difference of potential in 173 days from ·66 to ·5 Daniell. Then, on opening the instrument, it rose to ·67 Daniell. Experiments with an electrometer having quadrants of the metals under examination were made on the rate of decrease on the differ-

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ence of potential near two metals in contact, and exposed to the action of the air and of other gases; also where a change in the constituents of the atmosphere surrounding a pair of metals in contact reverses the difference of potential near them in correspondence with the reversal of electromotive force which takes place after a similar change in the corresponding liquid electrolyte used with the same metals as a voltaic cell. Such reversal takes place with pairs of copper-iron when hydrogen sulphide gas, or ammonia gas, is added to the air surrounding them; with silver-iron when hydrogen sulphide is added; and with copper-nickel when either ammonia or hydrochloric acid gas is added.

LIFEBOATS AND ELECTRICITY.—In the course of a leading article upon the recent disastrous loss of lifeboat crews, *The Times* of yesterday suggests that electricity might be made available as a motive power for lifeboat service. "Accumulators," thinks *The Times*, "might possibly be fixed so as to form a portion of the ballast." Certainly they might, though as ballast they would be somewhat expensive, and for any other purpose storage batteries would be utterly out of place in a lifeboat. It is decidedly unfortunate that the leading English journal should entertain such hazy ideas upon a matter of this character. Apart from such fundamental objections as to the impossibility of keeping the cells always in a condition for active service at a moment's notice, we doubt whether any makers of accumulators would be prepared to supply cells guaranteed to stand the amount of knocking about which must be undergone in such service. *The Times* is possibly unaware that accumulator cells cannot be hermetically sealed up. In this connection we may, however, mention that, notwithstanding this difficulty, the E.P.S. Company, after very numerous experiments, have recently succeeded in designing a form of cell which will bear repeated and rapid inversion without serious loss of liquid. In this case, however, the application is only upon a small scale, and any failure of action would tend to the preservation rather than the destruction of human life—that is to say, the cells were designed for use upon a self-propelling torpedo, which will shortly be brought out by Mr. Nordenfelt. One of the boats which capsized off Southsea made a voyage of 12 miles out to the vessel. We should be glad to get some idea of the power required to propel a boat with a crew of twelve men at the rate, say, of 10 or 12 knots an hour through a storm such as that of the 6th inst.

THE SNOWSTORM AND OUR LINES TO THE CONTINENT.—The *Standard's* Berlin correspondent states that the *National Zeitung* charges the English authorities with culpable negligence in connection with the existing interruption of telegraphic communication between England and the Continent. While in Germany, thanks to the subterranean lines, the wires are all in full operation down to the submarine cables, London is entirely isolated, owing to the indolent indifference of the British Government, which has failed to adopt the precautions which have for years proved so efficient in Germany. The *National* continues:—"Since Monday morning all telegraphic communication with England *viâ* Emden, Amsterdam, Brussels, Paris, and even *viâ* Friedericia and Arendal, has been interrupted by severe snowstorms, an interruption that causes loud and well-grounded complaints on the part of the public. The French cable ends at Dover, and the German at Lowestoft. The German subterranean is acting perfectly, in spite of the ordeal it has recently gone through. On inquiry in competent quarters we hear that all the telegrams from here to London, *viâ* Brussels, are sent by wire only to Ostend, whence they are transmitted to Dover by steamer, thus causing a delay of twenty-four hours. The cable from Ostend to Dover cannot be damaged, because this would otherwise have been notified; hence it is only the short terrestrial wire from the sea cable to the cable house at Dover that can be disturbed. This interruption, which most sensibly affects all commercial business, as well as political and social life, is due not to *force majeure*, but to the negligence of the English. Every violent storm, so often beating on England's southern coast, disturbs this short non-subterranean wire from the cable to the first office. Complaints have already been made times without number, but all in vain, owing to English red-tape. The line from Lowestoft to London is neither long nor technically difficult to keep in order. The English Government will be compelled in the end seriously to take the matter in hand, and to lay down a subterranean cable on that line. Its present condition is a source of vexation to the whole of Europe."

REMARKABLE METEOROLOGICAL PHENOMENON IN VENEZUELA.—The United States consul at Maracaibo, Venezuela, has furnished the following account of what he terms an "electrical eccentricity:"—"During the night of the 24th of October last, which was rainy and tempestuous, a family of nine persons, sleeping in a hut a few leagues from Maracaibo, were awakened by a loud humming noise and a vivid, dazzling light, which brilliantly illuminated the interior of the house. The occupants, completely terror-stricken, and believing, as they relate, that the end of the world had come, threw themselves on their knees and commenced to pray, but their devotions were almost immediately interrupted by violent vomitings, and extensive swellings commenced to appear in the upper part of their bodies, this being particularly noticeable about the face and lips. It is to be noted that the brilliant light was not accompanied by a sensation of heat, although there was a smoky appearance and a peculiar smell. The next morning the swellings had subsided, leaving upon the face and body large black blotches. No special pain was felt until the ninth day, when the skin peeled off, and these blotches were transformed into virulent raw sores. The hair of the head fell off upon the side which happened to be underneath when the phenomenon occurred, the same side of the body being, in all nine cases, the more seriously injured. The remarkable part of the occurrence is that the house was uninjured, all doors and windows being closed at the time. No trace of lightning could afterwards be observed in any part of the building, and all the sufferers unite in saying that there was no detonation, but only the loud humming already mentioned. Another curious attendant circumstance is that the trees around the house showed no signs of injury until the ninth day, when they suddenly withered, almost simultaneously with the development of the sores upon the bodies of the occupants of the house. This is perhaps a mere coincidence, but it is remarkable that the same susceptibility to electrical effects, with the same lapse of time, should be observed in both animal and vegetable organisms. I have visited the sufferers, who are now in one of the hospitals of this city; and, although their appearance is truly horrible, yet it is hoped that in no case will the injuries prove fatal."

SPECIFIC INDUCTIVE CAPACITY, RESISTANCE, AND RADIATION OF DIELECTRICS.—M. J. Currie has recently been engaged upon an important series of researches on the relation between the instantaneous specific inductive capacity, the conductibility, and the power of thermal absorption or radiation of dielectrics. In a note presented to the French Academy he has given a description of the methods employed, but we shall con-

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tent ourselves for the present with a quotation from the latter part of the paper in which the results obtained are summarised. It will be seen that, so far as they go, these results accord with the theory of Clerk-Maxwell, and this circumstance is the more interesting in view of the negative results of Mr. Shelford Bidwell's recent experiments upon the connection between diathermancy and electrolytic conductivity. (See *Electrician*, Nov. 19, 1886, page 35). A very striking fact (says M. Currie) is the great constancy of the values obtained for the instantaneous specific inductive capacity with the extreme variability of the values of the conducting power or resistance. All the different samples of the same substance (cut in the same direction for crystalline bodies) yielded the same values for the former quantity. It is, on the contrary, impossible to find any two samples giving identical results as regards specific resistance. It is not uncommon to find two plates of the same substance, apparently equally pure, which show values differing in the ratio of 5 to 1. Variation of temperature has little influence upon specific inductive capacity, but it has an enormous effect upon the conductivity, and upon cooling the resistance frequently does not regain its original value. In spite, however, of these causes of uncertainty, the relative conductivity of many dielectrics may be considered to be known with tolerable precision, because at the same temperature they often differ enormously from one another. For instance, the resistance of rock salt is about 10,000 times higher than that of glass. A perfect dielectric would be one which after an instantaneous charge would yield no current. All the substances (here examined) tend towards this condition as the temperature is lowered. M. Boltzmann has shown that crystallised sulphur is a very perfect dielectric. This research has shown that for moderate temperatures we may place both rock salt and fluor spar in the same category. As good dielectrics we have quartz (cut parallel to the optic axis), topaz (in planes of cleavage), mica, and ebonite. Lower down the scale we have the following bodies in the order named:—Iceland spar (perpendicular to the optic axis), quartz (in the same direction), sulphate of barium (in planes of cleavage), rose tourmaline, green tourmaline, alum, glass. Now it is interesting to compare the list here given with that of the same substances as placed by Melloni in the order of their absorbing and radiating powers:—Rock salt, sulphur, fluor spar, Iceland spar, quartz, glass, white topaz, sulphate of barium, tourmaline (dark green), alum. In a general sense, the relation indicated by Clerk-Maxwell between the conductibility and the absorbing power seems here to be verified. It is at least certain that the three most perfect dielectrics, rock salt, sulphur, and fluor spar, are also the three most diathermanous substances known. We may remark also that ebonite, which is one of the worst conductors, has been shown by Prof. Bell and Capt. Abney to be an excellent transmitter of radiant heat. We can scarcely yet affirm, however, that Maxwell's theory has received complete experimental demonstration in this particular, and, in fact, in the present state of our knowledge it would be almost impossible to obtain a precise verification, since, on the one hand, the strength of the current through a thin plate of a dielectric is a function of the time, and, on the other hand, the absorbing power depends on the length of the undulations of the heat waves. The figures given by Melloni correspond to an ill-defined group of radiations.

ROYAL COMMISSION ON THE TELEGRAPH SYSTEM.—The Royal Commissioners on Civil Establishments having suggested to the Postmaster-General that if the members of any particular class or classes desire to be heard specially by the Commissioners upon any matter within the terms of the Commission they should be at liberty to select representatives to give independent evidence. This suggestion the Postmaster-General falls in with, and has intimated to the telegraphists that if they wish to be examined by the Commissioners they should write direct to the secretary. This permission was expected, and in view of it meetings have been held in the principal towns to confer as to the evidence which might be required, and to appoint committees to collect and tabulate it. Circulars have been printed and sent to the various telegraph centres by the Telegraph Clerks' Association, asking for information on the various points which it is thought likely the Commission may inquire into. The telegraphists have decided to submit evidence bearing on salaries, which are alleged to be inadequate; on hours of labour, which are believed to be excessive, considering the tremendous strain on the nervous system of eight hours' continuous telegraphing; on annual leave; on the cost of staff; and on the administration and organisation of the telegraph system. It is stated that under the existing scales of pay—which were adopted by the late Mr. Fawcett in 1881, after a good deal of agitation carried on energetically by the telegraph clerks—it takes some fifteen years to attain the maximum salary of the lowest class, the pay being about equal to that of a mechanic. Promotion to the higher class is alleged to be very unsatisfactory. At Leeds, according to the *Telegraphist*, the senior second-class man has twenty-three years' service, and the man under him has twenty years; while at Sheffield, the same journal states, the senior second-class man joined in 1862, so that with 24 years' service he has only 38s. a week. The telegraphists intend to call the Commissioners' attention to the great difference in value of the superior appointments in the Postal as compared with the Telegraph Department. It is believed that no difficulty will be found in proving that the hours of duty—which are eight per diem—are too long. It is stated that evidence will be forthcoming that the sick-rate in the telegraph as compared with other departments is excessive, and that in recent years many superannuation allowances have been granted to clerks whose nervous systems have been completely shattered by the severe strain, and it is expected medical opinions will be submitted in support of these allegations. With regard to the cost and administration of the service, they state that the opinion of practical telegraphists should be of considerable importance. The telegraph vote for the current year is about £1,800,000, and something like 30 per cent. of this goes to the accounts department, while £41,000 is given to the secretary's offices. It is thought that by strict economy the accounts might be kept at a very much smaller expenditure. The telegraphists are anxious to see an alteration made in the organisation, by which it is hoped a saving will be effected in the pension list. They suggest that as it is admitted that telegraphists after 20 years' service are played out as operators, though as good as ever for ordinary clerical labour, the higher appointments in the Postal and Telegraph Departments, which presently are filled by youths who have passed the examination for the lower division, should be given to the senior telegraph clerks, thus removing them from the trying duties of a telegraph office, and for which they are no longer fit, before the inevitable break-down. If this were done the public would benefit by a reduced pension list and by better telegraphic service, while the higher branches would obtain the services of clerks who had gained a considerable and varied experience, which could not fail to be beneficial to the department to which they were transferred; besides, it would materially improve the flow of promotion in the telegraphs, the stagnation of which is a fruitful source of agitation.—*Glasgow Herald.*

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 143.)

[ERRATUM.—In the 21st line from bottom of column 1, page 142, of our last week's issue, *for* "arc lamps of 1,000 candle-power" *read* "arc lamps of 2,000 candle-power."]

It should be noticed that the opposing E.M.F. is independent of the strength of the battery urging the current, and would, therefore, be the same even if there were no battery. In the case we have considered the number of lines of force passing downwards through the circuit is increased, and the induced electromotive force is in the direction, east, north, west, south, so that the direction of the electromotive force is negative with respect to the lines of magnetic force. The same form of proof would also apply if the lines of force were cut at any angle instead of orthogonally. Hence we have the general law:—

When a conductor moves in a magnetic field an electromotive force is induced, represented by the *rate of diminution* of the number of magnetic lines of force passing through the circuit in a positive direction.

Lenz indicated the direction of the induced electromotive force by saying that

When a conductor moves in a magnetic field an electromotive force is induced, which tends to produce a current, which by its electromagnetic action would oppose the motion of a conductor.

This statement is known as Lenz's law.

If two coils of wire are placed near together and so as to be co-axial, and if a current be started in one coil, the lines of force due to the current will pass through that coil in the positive direction, and some of them will pass through the other coil in the same direction. Hence there will be a current induced in the second coil opposite in direction to that started in the first. On stopping the current in the first coil a current will be induced in the second in the same direction as that in the first, and will last until the primary current has died away.

Whenever the number of lines of force passing through a circuit is altered, whether by the motion of the circuit or of magnets or of other conductors conveying currents, or by the starting, stopping, or variation of currents in other conductors, there will be an electromotive force induced in the coil represented by the rate of diminution of the lines of force passing through the circuit in the positive direction; that is to say, if the number of lines of force passing through the circuit be increased the electromotive force will be in the negative direction with respect to them, while, if the number of lines of force be diminished, the electromotive force will be in the positive direction.

If lines of force pass vertically downwards, and a wire running east and west and forming part of a closed circuit be moved from south to north, a current will be induced in the wire from east to west, while a mechanical force will act upon the wire, urging it from north to south—that is, opposing its motion.

It is at first sight, perhaps, not easy to see the connection between the generation of a current by the cutting of lines of magnetic force through the motion of a conductor, and by the starting or cessation, increase or decrease, of a current in the neighbourhood of a conductor. The law that the electromotive force in a conductor is represented by the rate at which it cuts lines of force is equally applicable to all cases. Were it possible to generate instantaneously a current in a wire in the neighbourhood of a closed circuit, then a finite number of lines of force would, generally, be projected through the closed circuit in an indefinitely short time, and the *rate* of change of the number of lines of force passing through the circuit, and with it the electromotive force and induced current in the circuit would be infinite. But such a sudden generation of a current is impossible; in fact, its inductive action in its own circuit alone will limit its rate of increase. We must therefore remember that the generation or cessation of a current takes place by a continuous change occupying a finite time. Suppose A and B to be two wires, and a current to be started in A, while B is a portion of a closed circuit. At first the current in A will be indefinitely small, and its magnetic action will be distinguishable only very close to the wire. We may suppose that after a little one line of force drawn round the wire represents the whole of the magnet field. As the strength of the current in A increases this line of force will expand, and new lines of force will spring into existence around the wire, themselves expanding as the current is increased. One after another these lines of force cut across the wire B, causing a current to be induced in its circuit, the electromotive force in B being proportional to the rate at which these lines of force cut the conductor—that is, to the rate at which the current in A increases. Thus the effect upon B of an increasing current in A is exactly the same as though the wire B were moved across certain of the lines of magnetic force due to A. Sometimes in considering adjacent coils of wire we speak of the lines of force of the current in one coil as being projected through the other coil. If, however, we remember that the lines of force are all closed curves, that they originate close to the primary wire, gradually expanding as the current increases, we see that every line of force which passes once through a closed circuit must, in coming into this position, have cut the circuit itself. Suppose, for instance, that there are two coils A and B, and that when a current, C, flows in A there are n lines of force, due to this current, passing through B. If there be no current in A initially there will be no lines of force passing through B, due to the coil A. As the current in A gradually increases the lines of force due to the current in A will gradually expand, and one after another will cut the coil B until, at length, when the current C has been established in A, there will be n lines of force, due to this current which have cut the coil B and are passing through it. The result is the same, whether the current C take a long time to develop, or whether it be started in a time too short to be estimated. If the coil B contains m turns of wire, then each of the n lines of force cuts m wires, and the effect is the same as though $n\,m$ lines of force had cut or been cut by one wire. If the current C in the coil A be generated at a uniform rate, increasing from zero to its full value in one second, then $n\,m$ will represent the steady electromotive force induced in B during that second, the electromotive force being in the negative direction with reference to the lines of magnetic force. If a unit current in A causes $n\,m$ lines of force to pass through B, then $n\,m$ is called the coefficient of mutual induction of A and B, and it may be shown that a unit current in B would cause the same number of lines of force to pass through A. If a unit current be uniformly generated in the coil A, so as to increase from zero to its full value in one second, the electromotive force induced in B will be numerically equal to the coefficient of mutual induction of A and B.

If a current C is generated in a coil, A, at a uniform rate, so as to be increased from zero to its full value in t seconds, and if M be the coefficient of mutual induction between A and B, the electromotive force in B will be represented by $\frac{MC}{t}$, and if R denote the resistance of the circuit B, the current in it will be $\frac{MC}{Rt}$, and the whole amount of electricity which passes any section of the conductor B while the induced electromotive and current last—that is, during t seconds—will be $\frac{MC}{R}$. Now, MC represents the whole number of lines of force passing through B on account of the current C in A. Hence we see that the whole amount of electricity which passes through a secondary coil during the production or cessation of a current in the primary, is equal to the whole number of lines of force which pass through the secondary coil when the current in the primary has its maximum value, divided by the resistance of the secondary circuit.

Thus, while the electromotive force in the secondary circuit depends on the *rate of change* of the primary current, the whole amount of electricity passing through the secondary circuit depends on the whole change taking place in the primary and not on its rate. A good example of this is afforded by the Ruhmkorff coil. In this coil contrivances are introduced which enable the primary current to be stopped in an extremely

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short interval, while a very much longer period is required for its generation. Consequently the electromotive force in the secondary coil is very great indeed when the primary circuit is interrupted, but when the primary current is again started, the electromotive force in the secondary is comparatively feeble, and not sufficient to break through the air space generally left between the terminals of the secondary coil. Thus we get a spark at the "break" but none at the "make." If, however, the secondary circuit consist wholly of metal, so that Ohm's law is obeyed throughout, the induced current at the "break" will be very strong and of short duration; that at the "make" will be much feebler, but will continue for a proportionately longer time, and the whole amount of electricity passing through the circuit will be the same in the two currents. This result affords a good experimental proof of the truth of Ohm's law, for it shows that what has been called the resistance of the secondary circuit is the same, whether the electromotive force be very great indeed or comparatively feeble, and this is, as has been explained, the essential feature of Ohm's law.

The first observed phenomenon which depends upon electromagnetic induction was exhibited by the experiment of Arago's disc. A magnet was suspended horizontally, with its centre a little above that of a circular plate of copper. The copper disc was made to rotate rapidly, and a plate of glass introduced between the disc and the magnet to get rid of the effect of currents of air. Notwithstanding this precaution, the magnet was made to rotate, and to follow the disc. The experiment was repeated by Sir John Herschel and Mr. Babbage, and discs of various materials were tried, but only those which were good conductors of electricity produced any effect. No explanation satisfactory to Arago himself was offered until the experiments of Faraday developed, in the course of a few months, the laws of electro-magnetic induction which have been given above, and laid the foundation for the the introduction of the telephone, the magneto-electric machine, and the "dynamo."

In Faraday's earliest experiments he endeavoured to obtain a permanent current in one coil through the influence of a permanent current in a neighbouring coil, in accordance with the analogy of a permanent state of electrification produced in a conductor by the neighbourhood of a charged body, but his most delicate galvanometers failed to show any sign of a current when connected to the secondary coil. After repeated failures, and upon returning to the experiment after an interval of some years, Faraday, in 1831, observed an instantaneous deflection of the galvanometer connected with the secondary coil when the current was started or stopped in the primary. This put Faraday on the right tack, and his imaginative mind enabling him to see every magnetic field filled with magnetic lines of force, these served to guide him in his experiments, and in a few months he appeared to have investigated the whole of the subject of electromagnetic induction. Winding two coils of wire upon a ring of iron, and connecting one coil with a battery, the other furnished strong currents when the primary circuit was made or broken, the iron serving to conduct the lines of force from the one coil through the other. Winding a coil of wire around an iron bar, the ends were attached to two stout pieces of wire, one of which carried an amalgamated copper disc, while the other terminated in a point which just touched the disc. On letting the iron bar fall through a short distance upon the poles of a magnet, the shock caused the disc to separate from the point, while the induction current due to the sudden projection of the lines of force of the magnet through the centre of the coil was flowing. This caused a spark to leap between the disc and the point, and thus an electric spark was obtained from a magnet. The same result ensues whether the magnet be a permanent magnet or an electromagnet.

Faraday's investigations at once explained the experiment with Arago's disc. As the copper plate rotated it cut the lines of force, which diverged from the north pole or converged to the south pole of the magnet. This caused a current to flow along the diameter of the disc which was parallel to the magnet, the current returning by the circumferential portions of the disc. This current produced a mechanical stress between the disc and magnet tending to destroy the relative motion, and since the disc was compelled to turn the magnet was drawn after it. Faraday caused a copper disc to rotate between the poles of the magnet, a contact being made with the disc at its centre, and a second contact made by a spring pressing against the circumference of the disc at the extremity of the radius which passed between the poles of the magnet. A galvanometer being connected with the contact pieces, a current flowed through the circuit when the disc was made to rotate.

(To be continued.)

CORRESPONDENCE.

UNCOMMON MISTAKES IN ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At this festive season I beg to propose the following puzzles or conundrums to your juvenile readers:—

1. Why will not iron filings stick to the sides of a uniformly and longitudinally magnetised bar? (See *Electrician*, page 7, Nov. 12.)
2. What connection has the last with the question about the fish propounded by King Charles to the Royal Society?
3. Has *superficial* magnetism anything to do with the phenomenon?—Yours, &c., O. H.

RETORT CARBON PATENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been drawn to a paragraph in a paper by Mr. Swinburne on "Retort Carbon," which appeared in a recent issue of your paper.

Mr. Swinburne speaks of patents taken out and researches made by Messrs. Hughes, Rowland, Maxwell, and Chambers.

The Maxwell patent has nothing to do with retort carbon, and the only patent which I know of on the subject was taken out as the result of the joint work of Mr. Hughes and myself.—Yours, &c., ROLAND CHAMBERS.

December 29th, 1886.

LITERATURE.

The Gas Engine. By DUGALD CLERKE. (London: Longmans, Green and Co., 1886, pp. 279).

In a small handy book Mr. Clerke has succeeded in presenting to the world the best treatise yet existing on the gas engine.

Until within about five years very little was generally understood of the complex thermo-dynamics of the gas engine, but since that time several very able writers have devoted themselves to the elucidation of what was theoretically in a very unsatisfactory position. Gas engines, like other motors, had been made by practical men with a little or with no real knowledge of the actual behaviour of explosive or combustible mixtures in a closed vessel, and these men had gradually developed the engine until a good practical machine had been produced. More theoretical knowledge has been at the disposal of the most recent workers in this line, for with a practical success to provide information, scientific men have been able to systematise the facts presented, and by some experiments on moot points, to place before those interested in gas engines some of their ideas as to what was wanted, and to show that theoretically there were deficiencies which the practical man might, if he chose, grapple with until he stumbled upon the best means of removing them. Mr. Clerke is, however, one of those who have not only done as much, or more, than any other investigator and writer to present useful theory to the world on the complex problems involved in the construction and working of a gas engine, but he has produced an engine which has achieved very high efficiency, so high that one of his twelve-horse engines has given an indicated horse-power for a little over 20 cubic feet of

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gas per hour. He has been experimenting since 1876, and has in the ten years which have passed between then and the publication of his book acquired a more intimate knowledge of the gas engine in theory and practice than any other writer, and this has enabled him to appreciate the requirements of those who are most in want of a good book on the subject.

His first chapter is historical, and in this the history is of that kind which may be described as strictly technical as compared with anything apart from the gas engine itself and its development, or with anything personal to the several inventors. He is very careful to bestow credit where credit is due, and his praise of Herr Otto's inventions is noteworthy. His second chapter is on "the gas engine method," and may be looked upon as introductory to the third chapter, which is on "the thermo-dynamics of the gas engine." It relates to the method of heating and using the working fluid, the peculiarity of the gas engine being that the fuel and the working fluid are introduced into the motive cylinder and the fuel burned therein. It is to this method that the gas engine owes its great actual efficiency and its potential efficiency through the high temperature or high range of temperature which may be employed. He points out the steps in this respect which have led to the present engine. In the second chapter gas engines are classified, the classification being the same as that adopted by the author in his paper read before the Institution of Civil Engineers.* The first of the three classes is that including engines igniting at constant volume, but without previous compression, a type of which the Lenoir, the Hugon, and Bisschof are examples. The second type is of engines igniting at constant pressure with previous compression, and the third type includes the engines in which ignition takes place at constant volume with previous compression. The Brayton and the Simon and Simon Beechy and one of Atkinson's engines are the best known of the second type, and the Otto, Clerke, Tangye (Robson's), and Stockport (Andrews), and Atkinson differential are the best known, in the order given, of the third type. The author explains the classification and recalls attention to the earlier publication of the elements of the more modern engines in each type, and especially of the third type, which was very minutely set forth by Beau de Rochas in 1860 and by M. F. Million in the same year, though Otto was, as he admits, the first to apply the leading idea as set forth by these two, but not until 1876. The thermo-dynamic consideration of the gas engine leads now, as it did at the time of the author's paper already mentioned, to the conclusion that its efficiency depends upon the ratio between the initial temperature and the temperature of the adiabatic compression of the charge, and the temperature of the explosion may be any temperature greater than that without altering the efficiency. Dr. A. Witz published a very useful explanatory paper on the thermo-dynamics of the gas engine in the *Annales de Chimie Physique*, in 1883, an abstract of which appeared in the *Proceedings* of the Institution of Civil Engineers,† but Mr. Clerke points out what has apparently been overlooked, namely, that Dr. Witz assumed that the expansion of the gases after explosion expanded adiabatically as well as that they were compressed adiabatically, an error which needs only to be pointed out. The causes of loss in gas engines occupy the fourth chapter. These are examined as by one who is most anxious to find out every cause of loss with a view to improvements, and the examination is of a practical character, and many of the points involved lead directly to the details of the subjects of the next two chapters—namely, those on combustion and explosion, and on explosion in closed vessels. Upon both these questions Mr. Clerke has added more to our practical knowledge than perhaps any other investigator, and for the results we will refer to his little book.

In it he describes his apparatus and gives the curves obtained with various mixtures of different gases, showing pressures, rate of combustion, and temperatures, and thereby the best mixtures for engines of the different types. The gas engines of the different types in practice, the igniting arrangements, and other mechanical details occupy the next chapters, and these are followed by a chapter on "The Theories of the Action of the Gases in the Modern Gas Engine." In this chapter the author very cleverly discusses the theories as they have been expounded by Dr. Otto and by the several scientific men in England who support the almost absurd notion concerning the stratification of the charge in a gas engine cylinder even after compression, and no one can deny that Mr. Clerke has very fairly put all the best of the arguments of this school, and has equally well met them, and has thoroughly refuted them. In fact, if our patent law cases could be tried by a technical jury of a high class, the gas engine would never have been the subject of so much biassed statement as it has been, on more than one occasion important in the annals of invention and patent laws. In the chapter on the future of the gas engine Mr. Clerke gives a few indications which may be new to some, but most have probably been long seen by those best acquainted with this motor. He mentions some points of a thermo-dynamic order which are well worthy of close attention.

Mr. Clerke's book is clear and well arranged, and should be in the hands of everyone interested in the subject of gas engines.

* *Proc.* Inst. C.E., Vol. LXIX., 1882. †Vol. LXXVI., 1884.

ELECTRICAL WELDING.

At the meeting of the American Society of Arts, on December 9th, Prof. Elihu Thomson, of the Thomson-Houston Electric Light Company, read a paper on the subject of the "New Art of Electric Welding." The apparatus was shown in working order. One of the largest lecture rooms in the rear of the new building of the Massachusetts Institute of Technology was filled by about five hundred interested spectators. The following is the substance of Prof. Thomson's paper :—

In the past 15 years there has been a great expansion of the uses of electricity in the arts, the telephone, transmission of electric current for light and power. Of these, perhaps, in the future the transmission of power will be the most important. The energy of an electric current may produce mass motion (transmission of power), wave motion (telephony), light, chemical decomposition, and heat motion, which usually appears with the other transformations. The employment of heat generated by an electric current for the warming of buildings does not seem to be practicable ; the steam engine is so poor a converter of heat motion into mass motion that the efficiency of such a system would be very low. But in the arts where the amount of heat needed is small, or for sudden effects, or for high temperatures which are limited only by the vaporising point of carbon, heat produced by an electric current may be advantageously employed. An example of its successful employment is the Cowles electric furnace, in which the most refractory ores are reduced and metallic aluminium, boron, and silicon obtained directly from their compounds. In the dictionary definition of welding mention is made of the fact that tortoise shell could be easily welded. The lecturer remarked that he did not intend to experiment on tortoise shell. By the processes in common use it is difficult, if not impossible in many cases, to weld together different metals. Two pieces of the same kind of cast iron, zinc, tin, brass, and especially copper, have not been easily welded. By means of electricity they may be easily united. Iron, steel, and platinum, which have been the metals hitherto most easily welded, are by the new process still more readily united. To attempt by the new process to weld unlike metals may fail on account of a great difference in their temperatures of softening, or of their specific electrical and heat conducting capacities. The method is to forcibly press together two pieces to be united while passing a large current.

The method may be employed for joining into one continuous length short pieces of copper and iron wire. In the factory of the Thomson-Houston Company all joints in copper and iron wire are made in this way. The largest copper rod yet welded is a little less than ½in. diameter, requiring about 20,000 amperes. The same current will weld iron 1in. diameter, the difference in the size of the two metals being due to the greater resistance and lesser conductivity of iron. Specimens of various sizes, shapes, and materials were here shown ; cast iron, steel cast iron in one piece ; steel, brass, copper, also in one piece ; copper rod bent at joint after welding. Brazing can be done successfully by putting brass on a hot joint while current is passing. The smallest wires yet united by welding by this process have been $\frac{1}{50}$in. diameter.

Other specimens were butt welding of metal tubes, iron, brass, and copper, and lead. The iron pipes were hammered during the welding. Long lengths of cast or wrought iron pipe may be used in streets, a few bends being put in to allow for expansion and contraction. For making long lengths of pipes, for coils of pipe for boilers, and for other purposes, this method will be largely used, also for endless bands for saws, wheel tyres, tub, barrel, and tank hoops,

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iron and steel links. There will be a wide use for the method in the repair of tools and parts of machines such as the following, some of which are put to practical use in the Thomson-Houston factory :— Lengthening of screws, taps, augers, lag screw bolts, by cutting off the shank and welding in a piece of iron or steel. A tool may be shortened by cutting out pieces and welding together. Steel points are welded to cast iron bodies of lathe tools; shafts may be lengthened. A carpenter's auger lengthened by this process was broken after being twisted two turns, the weld still being sound. For jewellers, as well as for others, this process may be made useful. Less fuel is required by the electric method of welding, on account of the small time required for the operation and the application of the heat locally, and the small losses from radiation and conduction. The time required being so short more joints may be made in the same time by comparatively unskilled labour.

In arc light circuits a current of 10 amperes, with an electrical pressure of 2,500 volts, is not infrequently employed. In incandescent lighting a current of 250 amperes, at an electrical pressure or electromotive force of 100 volts, would represent the same amount of electrical energy. In welding wire enormous currents are employed ; 50,000 amperes, at an electrical pressure of ½ volt, would represent exactly the same amount of electrical energy. This amount of current would probably weld steel 1½in. in diameter in less than two minutes. Electric lights demand a continuous application of power, while the welding, for instance, of a 1½in. piece of steel would require 35 horse-power for only one minute, the same power being required continuously to operate 40 to 45 arc lights.

The means for obtaining sufficiently large currents are two— storage batteries and alternate current machines connected with transformers. The coil, Fig. 1, is composed of a bundle of fine iron wires,

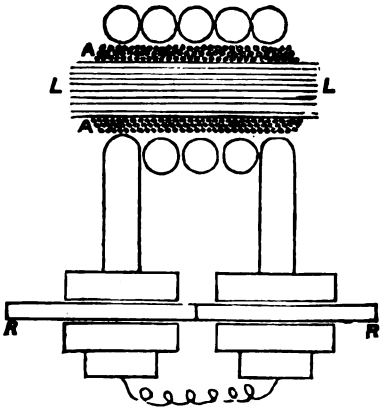

Fig. 1.

L L, around which are wound a number of layers of comparatively fine wire connected by the terminals A A to a source of alternating currents, a dynamo giving 50 to 100 alternations per second. The length of the iron core is 12in., the diameter about 1¼in. The secondary coil S S represented in the diagrams as composed of five turns of large copper, was in the smaller instrument shown composed of 64 No. 10 Brown and Sharp's gauge copper wires wound in parallel eight times around the primary. The ends were bolted to copper plates upon which the clamps are placed, one of which slides by an adjustable spring shown at the bottom of the diagram. By means of a cam the clamps may be separated to any extent. It takes only a few seconds to place the pieces of metal to be welded in the clamps. The iron core, on which the primary circuit is wound direct, may be pulled in and out. The power of the currents induced in the secondary coil is thus varied and adapted to any sized piece of forging. The resistance of the secondary coil is ·00015 ohm.

In the transformer or induction coil, illustrated in Fig. 2, the primary coil P P is a coil 12in. in diameter, 2½in. wide, and ¾in. thick, of many turns of insulated copper wire. The ends A A of this coil are connected with the alternating dynamo, and alternating currents thus pass through the wire of the primary coil. The secondary coil is a single heavy bar of copper bent to make one turn outside of the primary coil. The secondary is represented by the heavy black ring, the terminals of which, S S, are bent out to a parallel position and connected to massive screw clamps, M M. The secondary coil is shaped like a jew's harp. The parallel portions of this midway between S and M are made so that the clamp terminal M at the right may be moved. The screw C is used to force the terminals apart, the bars to be welded R R are clamped in position, the clamp C is unscrewed, and the tension of the spring D is adjusted by the screw attached to it. The pressure of the spring gives good contact of the bars R R. The primary and secondary coils are wound around with an endless coil of iron wire, I I I I. The iron wire does not touch the primary or secondary coils, but is wound on a sheet iron casing, the secondary coil thereby being free. The resistance of the secondary coil is ·00003, and under the influence of a good primary current gives an electromotive force of two volts ; less, however, is used in most cases. There is a small percentage of loss in the transformation ; a current of 20 amperes and 600 volts in the primary circuit gives in the secondary circuit nearly 1 volt and 12,000 amperes. To generate the alternating current an inexpensive dynamo is used, weighing 500lb., absorbing 25 horse-power at 1,800 revolutions per minute. There are 10lb. of copper wire on the armature, and 40lb. on the field-magnets. The large output from so small a machine without destruction comes from the fact that the machine gives current only for short intervals. There are suitable switches to stop the flow of current when the weld is complete. The primary circuit may be cut or the resistance in the circuit of the field-magnets of the dynamo may be varied, a method employed in the present case. To prevent overheating the primary coil of the machine illustrated in Fig. 1 may be pulled out to any extent, or resistance may be added to the primary circuit, or the strength of the field-magnets of the dynamo varied as described above.

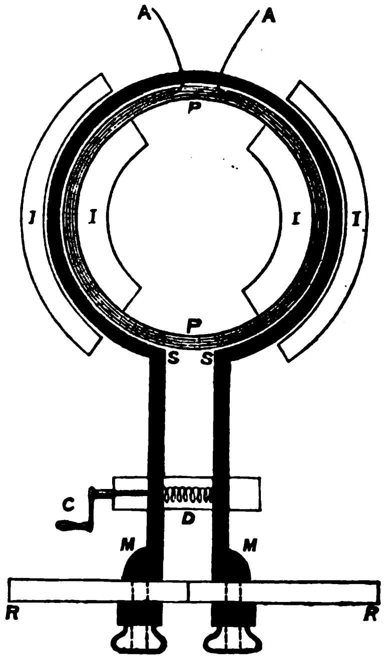

Fig. 2.

The ends of the pieces to be welded are brightened, and are allowed to project a little beyond the clamp when in position. A flux of some kind is now often put on the joint—powdered borax for metals that have a high melting point ; chloride of zinc, resin, or tallow for lead, zinc, and metals which have a low melting point. The current is now turned on, the ends of the rod become red, then white hot, and at the point of fusion soften ; the tension of the spring causes the joint to become upset or thickened. The current is shut off, the clamps unloosened, and the bar with the weld still red hot may be removed. Of course, many metals do not require even a red heat for fusion. In uniting a large to a small piece, the end of the large piece is first turned down to the size of the smaller. Sometimes the joints are hammered while in the clamps. It is probable that the result is caused by heat alone, though some electrical action may play a part. One circumstance tends to produce uniform heating of the abutting bars. Suppose one part of the surfaces is in much better contact than the rest. The larger part of the current will therefore flow in the path of least resistance. This part becomes hot, its resistance increases in consequence, and the current is to a large degree diverted to the colder portions of the joint, until the whole of the abutting surfaces are equally heated. There is no reason why cheap water power may not set in motion dynamos generating alternate currents of high electromotive force. Such currents may be transmitted with little loss over long distances, and by suitable transformers changed into currents suitable for welding. Accurate tests are to be made at once of the strength of the welds produced by this process. All practical tests applied thus far show that the joint is fully as strong as any other part. A lag screw, a portion in the centre of which was cut out, and the ends rather poorly welded without expansion of the joint, when turned into hard wood broke below the weld ; the break was sound. A penknife was shown, the two new blades of which had been welded to stumps projecting ⅛in., without removing them from the tortoise shell handle, which was not welded by the operation. In another knife a new blade, welded on by this process, was broken, but not at the weld.

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THE ELECTRICIAN.

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CONTENTS.

Notes ... 159
Elementary Electricity and Magnetism—II. (Continued.) 164
Correspondence ... 165
Literature ... 165
Electrical Welding. Illustrated 165
LESSONS OF THE STORM ... 168
Practical Deductions from the Franklin Institute Tests of Dynamos. By Carl Hering. 169
The Self-Induction and Resistance of Compound Conductors. By Lord Rayleigh, D.C.L. ... 170
The Newcastle Exhibition ... 172
Some Experiments on Secondary Cells. By J. Swinburne. (Continued) ... 173
Dynamo-Electric Machinery. By J. Hopkinson, M.A., and E. Hopkinson, M.A. (Concluded.) Illustrated ... 175
The Testing of Dynamos and Motors ... 177
The Telegraphic Breakdown ... 177
Concert by the Staff of the Eastern Telegraph Company 178
Companies' Meetings—
New Telephone Company (Limited) ... 179
Simplex Electrical Syndicate (Limited) ... 179
The Pilsen, Joel, and General Electric Light Company (Limited and Reduced) ... 180
Companies' Share List ... 180

LESSONS OF THE STORM.

The terrible storm of last Sunday night, although a subject of universal regret, is not to be passed over with the ordinary expressions of sympathy which visitations of that kind usually evoke. In the first place, injury to life and limb has been wonderfully small, the chief damage being confined to property, and this, too, not of private individuals, but of public companies and the State. Traffic has been greatly delayed on the railways owing mainly to the break down of electric signalling appliances, upon which our railway system has so long depended for its safe working. It was the electric telegraph that suffered most by the combined attacks of snow and hurricane, both in the metropolis and on the railways in its neighbourhood for many miles round. And the noticeable feature about this, as about the similar storm twelve months ago, was that, humanly speaking, those who have suffered are the people who deserve to suffer, whilst the unoffending people whose safety is continually jeopardised, in towns at least, by the overhead wires which are now lying about the streets in hopeless wreckage and confusion have miraculously escaped. This is a matter to be heartily thankful for; but the fact cannot be used as a proof of the safety of the system. Holiday time, Sunday, and the night, had fortunately emptied the streets. That is all that can be said. On Monday morning there was enough broken wire on the footways to have slaughtered a goodly number of victims had they been in the way instead of being in their beds. Travellers by night trains were not quite so fortunate; but here, again, there is a quite providential absence of serious accidents due to the falling of telegraph poles. The injury sustained is mostly of a pecuniary kind, and it will not fall upon the blameless.

What amount of actual damage has been done it would be difficult to estimate at present. Scarcely a railway line leading out of London has escaped with its telegraph poles and wires intact, and on the majority they have been wholly or nearly wholly disabled. Between Paddington and Didcot alone the broken poles number from two to three hundred; and on the Chatham and Dover and the South-Eastern railways the havoc to all appearance is not much less. The cost of re-erection will be very serious, the more so as in some instances the poles and wires had been renewed quite recently, and special precautions taken to ensure their stability. As a rule the telegraph poles, with their enormous burden of wires, are, in spite of their menacing appearance, beyond the reach of the trains, and the care that is taken in their erection renders them practically safe from doing anybody or anything the least harm even in the improbable event of their giving way. The storms of the present year have tried the systems most severely, and under this last one, which was of almost unprecedented violence, they have succumbed. But no positive blame attaches either to the Railway Companies or the Post Office authorities for what has happened. Probably no aerial system of telegraphs possible under the conditions necessary for the telegraphs of this country could have stood up against such a storm uninjured; and nobody would propose to put the existing aerial system underground, even if it were blown down more frequently than it is. Our sympathy is due to the owners of this property which has just been so unavoidably lost; and on the whole we think the railway companies are to be complimented for the promptness with which they adopted temporary expedients for signalling purposes that speedily enabled the trains to run with their accustomed punctuality. As regards the Post Office wires, the time has surely arrived for laying down supplementary lines underground to such of the great provincial towns as are not yet provided with them, and to the continental cables, which at present are rendered utterly useless through the breakage of a few land wires on our side of the Channel. A bitter complaint on this score reaches us from Germany, and will be found in another column. Still, in respect to the great bulk of the wires, their destruction can only be regarded as a national misfortune, which could not be avoided, and which we all deplore.

To the owners of aerial wires in the metropolis and suburbs we cannot, for obvious reasons, extend this sympathy, and we make haste to protest against the use that is being made of the disaster as a whole to cover the blame in respect to a particular portion of it. That the railway and roadway telegraph lines have been destroyed is no justification for the destruction of overhead wires in populous towns, nor is the actual immunity from personal injury in respect to both systems any excuse for the danger deliberately incurred by one of them. The wires that run by the side of the railways and along the highways are, we repeat, generally safe; those that run over our heads in the main thoroughfares of towns and cities are always unsafe. The latter are not so strong, and are not so carefully erected; the spans are often longer, and their poles often overtaxed; but more particularly they threaten passengers underneath, whereas the lines on the roads and railways imperil nobody. There is, therefore, no parallel between the two cases; and the only question remaining is whether the urban telegraph, or more correctly telephone, wires are of themselves perfectly secure. The answer to this question was partially answered by the storm of January last; and com-

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pletely answered by the condition of London streets to day. Poles are still standing, and plenty of them; and there are numberless wires which to all appearance are in good condition; but look in whatever direction and locality we may, the rule is that both poles and wires have suffered disastrously. Quantities of broken wire hang down either sides of the streets, or are saved from falling only by being entangled in wires that have stood the brunt of the storm. In many instances the iron poles are bent into grotesque shapes, and the wires slacked into inextricable entanglement; while in not a few places complete breakage has happened, the poles overhanging the parapets with a mass of wire clinging to them, which any fresh gale of wind would precipitate headlong into the streets. The injury done to roofs and chimney stacks by falling poles and wires is not visible from the streets, but from more advantageous points of inspection we can certify that the devastation is as widespread as the most enthusiastic advocate of underground wires could desire. No one can say that the telephone companies, who are the chief sufferers, have not had plenty of warning, and no one can pity them for having paid no heed to it.

So very conspicuous are the effects of last Sunday's storm that the London newspaper press has given an unusual attention to the subject, with the result that the long delayed demand for putting these wires in safety underground is now being urged with greater vigour than ever. We trust that the Metropolitan Board of Works and the London vestries will not neglect to improve the occasion. It is our belief that much might be done by these authorities in the way of prohibition without any sanction of Parliament at all—much that the telephone companies would never dare to challenge in a court of law, for public opinion would be almost entirely on the side of restrictive interference. As a mere matter of police, the perilous condition of hundreds of wires which are now loosely festooning Fleet-street and the Strand might be peremptorily cured by cutting the wires adrift; and it would be the fault of the parishes if these wires are ever allowed to resume their former position. But we trust that no high-handed measures of this kind will be necessary. The shareholders of the companies by this time have surely had lessons enough in the expense of restoring communication to be satisfied that the safer system would be the cheaper. Not only have they to bear the cost of repairs and renewals, but the certain loss of custom. Renters will be chary of repeating their subscriptions to a system so easily put out of gear, and liable periodically to an utter break down for days and weeks at a stretch. Parliament, however, meets in about a month's time, and if directors of the Telephone Companies who disfigure and endanger the streets of London do not voluntarily reconsider their ways before then, we sincerely hope that powers to compel them will be sought for as soon as the Legislature assembles.

PRACTICAL DEDUCTIONS FROM THE FRANKLIN INSTITUTE TESTS OF DYNAMOS.*

BY CARL HERING.

The tests of dynamo-electric machines, made in 1885, under the auspices of the Franklin Institute are undoubtedly the most reliable and complete of all the impartial tests which have ever been made and published, and they therefore afford the practical electrical engineer an excellent opportunity to deduce proportions, dimensions and constants, to assist him in designing dynamos, especially as the machines which were tested are among the best that are made, and represent the results of tedious and expensive experimenting on the part of the makers, while at the same time they embody the improvements suggested by long and continued use of the machines in practice.

Dynamos have frequently been built by "guessing" at the proportions, constructing them, and then trying them to "see what they will give." If they then turn out (by chance) to give the electromotive force and current desired, the designer generally gets the credit for having made very correct "calculations;" while if they give, for some unknown reason, quite different results, the manufacturer has to be consoled with the statement that "it is not possible to calculate the parts of a dynamo."

If a machine is at hand which can be thoroughly tested and measured in all its parts, it is not difficult for a technical engineer who is well informed concerning the principles and practice of dynamo building to calculate the parts of another machine of the same type which will give a certain desired electromotive force and current slightly different from that of the first machine. But when the designer has no access to such a model machine, or if the current and potential desired differ greatly from those of the model, it is difficult, if not quite impossible, to calculate with any degree of certainty the parts of a dynamo from the principles and laws of induction and resistance without some practical constants and proportions, which can be obtained only from existing machines.

As an aid and guide in such calculations, a set of practical constants and proportions have been calculated by the writer from the valuable tests of the Franklin Institute. These constants will not only materially diminish the amount of "guessing" in designing machines, but it is believed they are sufficiently complete to enable a technical engineer to calculate all the electrical proportions of a well-designed cylindrical armature which is to give a certain required electromotive force and current. It is to be regretted that the data given in the Franklin Institute report are not sufficient to enable a similar complete set of constants to be deduced for the field. The calculations of armatures being based on induction and conductivity, the constants from one armature may be used in calculating others; but in the field this is not the case, as the relation between the exciting current and the magnetism produced depends very largely on the size, shape and proportions of the coils and the iron parts, including the cores, the so-called neutral parts, pole-pieces, &c, as well as on the quality of the iron. As these are so very different in different machines, the constants obtained from one would be of little use in determining the size of other fields, except perhaps, the constants given below for the intensity and amount of the magnetism of the field. A careful and systematic builder of dynamos will, in most cases, run the armature, when completed, with its own field-magnet frame with temporary, removable coils of known number of turns, on the magnets, in order to find, by regulating the current in these temporary field coils, how many ampere-turns are required in the field to induce the desired electromotive force and current in the armature. From this number of ampere-turns any competent dynamo builder can readily calculate the proper windings of the magnets with all due accuracy.

Numerous theories of dynamo-electric machines have been advanced, but most of them are of greater interest to the mathematician and the physicist than to the practical dynamo builder. More attention seems to have been given to integrals, complicated abstruse fractions and formulæ for determining the presumably correct values for extreme impossible cases, than to simple, practical formulæ, by means of which tangible results may be obtained for the ordinary forms of machines. In some cases, formulæ based on physical theories have been suggested, which might have been of practical use if accompanied by the absolute and reliable values of certain constants usually represented by Greek letters, which enter as direct factors in the formulæ; but the values of these constants have either been omitted, or else have been given within such wide ranges that they cannot be used to any advantage in practice. They are sometimes of such a nature that they differ for each machine, thus necessitating the construction and testing of the machine before the values of the constants for calculating this particular machine may be determined; which is, to say the least, a very awkward way of applying a formula.

* From the *Journal* of the Franklin Institute for December.

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—	Ref. Let.	Edison, No. 4.	Edison, No. 5 or *T*.	Edison, No. 10 or *S*.	Edison, No. 20 or *H*.	Weston, 6 *M*.	Weston, 6 *W I*.	Weston, 7 *M*.
External diameter of armature in inches	*a*	7·063	7·875	10·625	10·625	8·031	8·250	9·375
Internal diameter or diameter of the core	*b*	6·250	7·063	9·688	9·688	7·387	7·410	8·595
Mean diameter in inches	*c*	6·657	7·469	10·156	10·156	7·709	7·830	8·985
Speed in revolutions per minute	*d*	1600·	1400·8	1208·6	1092·1	1114·9	1257·6	1043·5
Mean inductor velocity in feet per second	*e*	46·5	45·6	53·6	48·2	37·4	43·0	41·0
Number of coils or commutator bars	*f*	50	50	64	44	72	56	64
Number of turns per coil	*g*	2	2	1	1	2	2	2
Total number of turns on armature	*h*	100	100	64	44	144	112	128
Mean distance between pole-piece projections in inches	*i*	2·69	2·313	3·50	4·88	2·52	2·58	2·94
Active part of circumference of armature in per cent. (approx.)	*j*	76	80	80	71	80	80	80
Length of pole-piece or armature core in inches	*k*	12·	13·	16·5	29·5	14	14	16·5
Total E.M.F. in volts	*l*	131·91	131·5	129·35	129·60	127·17	136·22	165·58
Mean induction in volts per foot	*m*	1·733	1·515	1·838	1·687	·948	1·304	1·175
Volts per foot for one foot per second	*n*	·0373	·0332	·0343	·0350	·0254	·0303	·0287
Mean intensity of field, in lines of force per square inch	*o*	25900·	23000·	23800·	24260·	17630·	21000·	19900·
Amount of magnetism in field, in lines of force	*p*	2660000·	3090000·	5250000·	8600000·	2490000·	3042000·	3860000·
Energy in field in horse-power	*q*	·394	·401	·675	·862	·207	·402	·498
Useful lines of force per volt-ampere in field (relative efficiency of field)	*r*	90·2	103·1	104·1	133·5	161·1	101·5	1037·
Length of wire in one coil in inches	*s*	92·	102·	68·	98·	154·	151·	160·
Total length of armature wire in feet (parallel wires considered as one)	*t*	383	425	363	359	924	705	853
Available active length in feet	*u*	152·0	173·4	140·8	153·6	268·8	209·0	281·6
Percentage of total, which is active	*v*	40	41	39	43	29	30	33
Diameter of bare armature wire in inches	*w*	·148	·180	·199	·199	·141	190	·175
Number of wires in parallel	*x*	1	1	2	3	1	1	1
Total current in armature	*y*	84·42	103·31	205·50	302·42	72·84	100·60	128·16
Square mils. of cross-section per ampere	*z*	407	492	606	475	428	562	374
Percentage of energy in armature	*A*	3·70	4·65	3·12	3·39	5·43	3·09	5·59
Total electrical energy in horse-power	*B*	14·93	18·23	35·67	68·25	12·43	18·39	28·47
Relative efficiency of armature as an inductor	*C*	11·33	8·44	7·90	10·17	4·32	4·62	6·94
Useful commercial efficiency of machine	*D*	88·38	89·76	89·70	91·90	87·38	90·21	89·92
Depth of winding in inches	*E*	·407	·406	·469	·469	·322	·420	·390
Percentage of diameter taken up by windings	*F*	11·5	10·3	8·83	8·83	8·02	10·2	8·32
Distance between pole-piece projections divided by depth of windings and clearance	*G*	5·0	4·4	5·9	8·2	5·65	4·75	5·72
Ratio of length to diameter of armature core	*H*	1·9	1·8	1·7	3·0	1·9	1·9	1·9
Ratio of length to diameter of bearings	*I*	4·2	4·3	4·1	4·1	4·2 & 3·6	4·2 & 3·6	3·8 & 4·3
Volts per commutator bar	*J*	6·7	6·25	4·9	7·2	4·2	5·9	6·1

The writer has, therefore, set aside all abstruse theories of the dynamo, which have yet to stand the severe test of varied practical application, and has endeavoured to deduce from the results given in the Franklin Institute report some constants, or values, which are in such a form that they may be directly applied to the calculations of the armature and some parts of the field. The deductions of these constants are based only on the well-known laws of induction and of mechanics, and as they are calculated from actual cases, they show what *is* done in practice, as distinguished from what *might be* done according to some theory, provided the theory is correct.

The results tabulated on the following page not only give the values which can be used in designing machines, but an attempt has also been made to determine the efficiency of separate parts, thus indicating under what circumstances the most advantageous proportions may be arrived at. Some proportions used in calculating the numbers given in the table were not contained in the report, and therefore had to be estimated, except where they were furnished to the writer by the kindness of the manufacturers. But the errors which may have been introduced by a slightly inaccurate estimate are so small that they do not materially affect the results. Certain slight errors, or modifications, in some of the figures or proportions were not taken into account, as they cannot be determined; but they are of such a nature as to affect equally, or approximately so, all machines not differing too widely from the style of those tested. Among these is the self-induction of the armature; in well-built machines, like those tested in which the field is intense, the speed not too high, the number of commutator bars or coils large, and the number of windings per coil very small, the self-induction will be very small, and, therefore, the difference between the self-induction in these different armatures may be neglected.

In the table given below, the deduced constants have been accompanied by many of the proportions from which they were derived, as copied from the report, in order to show some of the principal proportions of the machines, and to give the conditions under which the constants have the values given. Numerous other values in the report might have been repeated here, but as it is presumed that any one can obtain the original report, they are omitted. The values chosen for the deductions were taken from that one of the full load tests in which the current and potential were nearest to the values given by the makers as the best working load. (*See Table.*)

(To be continued.)

THE SELF-INDUCTION AND RESISTANCE OF COMPOUND CONDUCTORS.*

BY LORD RAYLEIGH, D.C.L.

Before entering upon the proper subject of this communication, I take the earliest opportunity of correcting a mistake of some importance into which I fell in connection with induction-coils. From the fact that a closed magnetic circuit acts very ill as a store of energy, I argued that closed electromagnets were to be condemned as secondary generators (*Phil. Mag.*, August, 1886, p. 179). Dr. Hopkinson and Prof. Ewing have independently drawn my attention to the fact that the success of induction coils does not depend upon storage of energy, and that they might work with high efficiency even though the whole of the energy put into the iron were wasted. Prof. Ewing's remark, to which I took exception, is thus perfectly correct.

I propose in the present paper to give an account of some investigations, mainly experimental, carried on during the summer months, which may, I hope, tend to settle some of the controverted questions which have been raised by the series of interesting experiments which were described in the spring of this year by Prof. Hughes.

Prof. Hughes's first apparatus consists of a Wheatstone quadrilateral, with a telephone in the bridge, one of the sides

* *Philosophical Magazine*, December, 1886.

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of the quadrilateral being the wire or coil under examination, and the other three being the parts into which a single German-silver wire is divided by two sliding contacts. If the battery-branch be closed, and a suitable interrupter be introduced into the telephone-branch, balance may be obtained by shifting the contacts. *Provided that the interrupter introduces no electromotive force of its own*,* the balance indicates the proportionality of the four resistances. If P be the unknown resistance of the conductor under test Q, R the resistances of the adjacent parts of the divided wire, S that of the opposite part (between the sliding contacts), then, by the ordinary rule, $PS = QR$; while Q, R, S are subject to the relation

$$Q + R + S = W,$$

W being a constant. If now the interrupter be transferred from the telephone to the battery-branch, the balance is usually disturbed on account of induction, and cannot be restored by any mere shifting of the contacts. In order to compensate the induction, another influence of the same kind must be introduced. It is here that the peculiarity of the apparatus lies. A coil is inserted in the battery and another in the telephone branch, which act inductively upon one another, and are so mounted that the effect may be readily varied. The two coils may be concentric and relatively movable about the common diameter. In this case the action vanishes when the planes are perpendicular. If one coil be very much smaller than the other, the coefficient of mutual induction M is proportional to the cosine of the angle between the planes. By means of the *two* adjustments, the sliding contact and the rotating coil, it is usually possible to obtain a fair silence.

In his address Prof. Hughes interpreted his observations on the basis of an assumption that the self-induction of P was represented by M irrespective of resistance, and that the resistance to variable currents could (as in the case of steady currents) be equated to QR/S. In the discussion which followed I pointed out that this was by no means generally true, and I gave the following formulæ† as applicable to the case in which the only sensible induction among the sides of the quadrilateral is the self-induction L of the conductor P :—

$$QR - SP = p^2 ML, \quad . \quad . \quad . \quad (1)$$

$$M(P + Q + R + S) = SL. \quad . \quad . \quad . \quad . \quad (2)$$

The electrical vibrations are here supposed to follow the harmonic law, with frequency $p/2\pi$. "It will be seen that the ordinary resistance balance ($SP = QR$) is departed from. The change here considered is peculiar to the apparatus, and, so far as its influence is concerned, it does not indicate a real alteration of resistance in the wire. Moreover, since p is involved, the disturbance depends upon the rapidity of vibration, so that in the case of ordinary mixed sounds silence can be attained only approximately. Again, from the second equation we see that M is not in general a correct measure of the value of L. If, however, P be very small, the desired condition of things is approached; since, by the construction of the apparatus, $Q + R + S$ is constant (say W), and if P be small enough S does not differ much from W, *i.e.*, most of the wire forming the three sides of the combination is devoted to the member opposite P."

The formulæ are easily proved. Since there is no current through the bridge, there must be the same current (x) in P and one of the adjacent sides (say) R, and for a like reason the same current y in the sides Q and S. The difference of potentials at time t between the junction of P and R and the junction of Q and S may be expressed by each of the three following equated quantities :—

$$Qy - Px - L\frac{dx}{dt} = -M\frac{d(x+y)}{dt} = Rx - Sy;$$

from which the required results are obtained by elimination of the ratio $x : y$, and introduction of the supposition that all the quantities very harmonically with frequency $p/2\pi$.

The inadequacy of Prof. Hughes's original interpretation has been remarked upon also by Prof. Weber‡ and by Mr. O. Heaviside,§ who have obtained the corrected formulæ. I give them here because I agree with Prof. Weber that this form of apparatus possesses distinct advantages. As he points out, if P be known, the application of (2) really presents no difficulty, and allows of L being readily found in terms of M.

There are many cases in which we may be sure beforehand that P (the effective resistance of the conductor, or combination of conductors, to the variable currents) is the same as if the currents were steady, and then P may be regarded as known. There are other cases, however—some of them will be treated below—in which this assumption cannot be made; and it is impossible to determine the unknown quantities L and P from (2) alone. We may now fall back upon (1). By means of the two equations, P and L can always be found in terms of the other quantities. But among these is included the frequency of vibration; so that the method is only practically applicable when the interrupter is such as to give an absolute periodicity. A scraping contact, otherwise very convenient, is thus excluded*; and this is undoubtedly an objection to the method.

My own experiments have been made with three different forms of apparatus. The first was constructed upon the model of that originally described by Hughes, and still to be preferred for some purposes. The others will be described in due course; but it will be convenient to consider first those parts which are common—the interrupters and the induction-compensators.

A thoroughly satisfactory interrupter with a definite period has not, to my knowledge, been constructed. Tuning-forks, driven electro-magnetically with liquid or solid contacts, answer well so long as the frequency required does not exceed 128 or 256 per second; but here we desire frequencies of from 500 to 2,000. My experiments have been made with harmonium-reeds as interrupters, the vibrating tongue making contact once during each period with the slightly rounded end of a brass or iron wire, which can be advanced exactly to the required position by means of a screw cut upon it. Blown with a well regulated wind, such reeds have given good results even up to 2,000 (complete) vibrations per second; but they are often capricious and demand frequent readjustment. The reed which I have usually employed makes about 1,050 vibrations per second, and answered its purpose fairly well.

The induction compensator is similar to that used by Prof. Hughes, and consists of a small coil mounted so that one diameter coincides with a diameter of a larger coil, and movable about that diameter. The mutual induction M between the two circuits depends upon the position given to the smaller coil, which is read off by a pointer attached to it, and moving over a graduated circle. The circles are so divided that the reading (θ) would† be zero when the *axes* of the coils were coincident, or the planes parallel. In this position M is arithmetically a maximum (M_0); and we consider its algebraic sign to be positive. At 90°, when the axes are at right angles, $M = 0$. At 180° M would be negative, and of the same arithmetic value (M_0) as at 0°.

The coils are wound upon boxwood rings, and in each there are 45 convolutions. The mean diameters are about 3in. and 1½in.

Lord Rayleigh next described the method by which the calibration of the compensators was performed. He then proceeds :—These results led to the unexpected conclusion that from 40° to 140°, *i.e.*, through a range of 100° about the perpendicular position, the scale of induction does not differ appreciably from the scale of degrees. From 30° to 40°, or from 140° to 150°, the induction is something like a tenth part less than that corresponding to 10° in the neighbourhood of 90°. Within the whole mechanical range of the instruments, from 30° to 150°, there could scarcely be an error of 2 per cent. in assuming M proportional to the angle measured from perpendicularity, *i.e.* $(\frac{1}{2}\pi - \theta)$, or, say, θ'.

The general explanation of this very convenient property is not difficult to understand; since for high values of θ' the approximation over the whole circumference of coils of not very unequal diameters must lead to a more rapid increase of

* This condition is not always satisfied. With the reed-interrupter (see below) a loud sound may sometimes be heard, although the battery-branch be open. † *Jour.* Tel. Eng., Vol. XV., p. 54.

‡ *El. Rev.*, April 9, 1886; July 9, 1886. § *Phil. Mag.*, August 1886.

* A toothed-wheel interrupter, as usually employed, does not give a regular vibration of the period corresponding to the passage of a tooth.

† The position is mechanically unattainable.

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M than if the smaller coil were very small; and it is conceivable that for some particular ratio of diameters the increase may just so much exceed that represented by sin θ', as to correspond nearly to θ'.

The absolute value of the induction-coefficient corresponding to each degree of the compensators was determined at the time of the calibration by comparison with the calculable induction-coefficient between two coils wound in measured grooves cut on the surface of a wooden cylinder.

By this means it was shown that every degree of either compensator, not too far removed from the middle of the range, represents 776·3 centim. of induction-coefficient.

The maximum coefficient, when $\theta = 0$, would be about 56,100 centim.

(To be continued.)

THE NEWCASTLE EXHIBITION.

The contracts for the electric lighting of this Exhibition have been awarded as follows:—Messrs. Clark, Chapman, Parsons and Co., for lighting the whole of the courts of the building, and to supply engines and boilers; Messrs. J. H. Holmes and Co., for lighting the Art Gallery; and Messrs. Paris and Scott, for lighting a portion of the inner garden. The tenders were sent in on the basis of the following specification:—

Conditions under which the Executive Committee are prepared to receive Tenders for Electric Lighting.—The Executive will provide engine-power, counter shaft, and driving drum; also foundations and holding-down bolts for the dynamos; and shall be responsible for providing the stipulated brake horse-power on the counter shaft, and linear velocity of periphery of driving drum. Contractors are to provide driving belts from counter shaft to dynamos, and to be responsible for the efficient working of all parts from the counter shaft to the lights.

Persons tendering are to specify the brake horse-power required on the counter shaft, and the linear speed of belt. If their tender is accepted, they are forthwith to send to the engineer of the Exhibition a templet, corresponding to the base plate of the dynamo or dynamos proposed to be employed, to enable the executive to prepare the necessary foundations.

In cases where the engine is on one foundation with the dynamo, or for any other reason the persons tendering wish to provide their own engines, the tender is to specify the nature and approximate dimensions of the engine employed, the steam pressure in lbs. per square inch above atmospheric pressure, the number of lbs. of steam per hour required, and the dimensions of the steam pipe. The executive will then be responsible for the supply of steam, but the contractors must be responsible for the efficiency of all parts beyond the steam connection provided. The foundations of the engines will be provided by the executive, according to specification to be supplied by the contractor.

Contractors are to supply all driving belts, dynamos, leads, switches, cut-outs, lamps and fittings, carbons, and all other requisites, with all fixing and labour; and to be responsible for the efficient carrying out of the work.

Each contractor shall apply one volt meter and one current meter, suitable for each type of installation for which he is responsible.

Every arc lamp outside the building shall be provided with a suitable reflector, placed above it, and not less than 2ft. 6in. in diameter; and every 50-candle incandescent lamp shall be provided with an opal glass reflector, not less than 7in. in diameter.

No leads shall be carried on the outside of the building, nor shall the contractors or their *employés* have access to the outside of the roof, on any pretext whatever. Every facility shall be given to contractors to carry their leads anywhere within the building, consistent with the safety of the public and the availability of the space for exhibits, provided that cables shall not be carried in open spans where, in the opinion of the executive or their superintendent, such spans are a disfigurement to the building.

All work shall be done by the contractors to the satisfaction of the agents of the several insurance companies interested in the building and contents, and safety cut-outs shall be inserted in the leads wherever required by such insurance agents.

If it is proposed to employ continuous currents of a higher E.M.F. than 400 volts, or alternating currents of higher E.M.F. than 200 volts, the tender shall be accompanied with a detailed specification of the precautions which it is intended shall be taken to provide against fire risks, and for the safety of the public and of the attendants.

The accompanying plan shows the number and character of the lights which it is proposed to place in the several sections; but the executive reserve the right to alter the position of any lamp or lamps, provided that such alteration does not necessitate an increased amount of lead.

As it will not be possible in all cases to give to persons tendering the particular section selected by them, it is desirable that each tender, while specifying the section preferred, should quote for more than one section.

Any person tendering may substitute incandescent lamps, in groups, or otherwise distributed (the mode of distribution to be described in the tender), for any arc lamps marked on the plan, according to the following scale:—For every 350 watt lamp, incandescent lamps of 500 nominal candle-power; for every 500 watt lamp, incandescent lamps of 800 nominal candle-power; for every 750 watt lamp, incandescent lamps of 1,200 nominal candle-power, and such tenders will receive the same consideration as those based on the distribution of lamps shown in the plan.

Any person may tender for one or more, or for *all* the nine sections mentioned below, but each tender must specify the sum to be charged according as one or more sections are allotted.

Each tender to state what additional sum per lamp is to be added if the number of lamps is increased by any number not exceeding 30 per cent. of the number specified, and the executive reserve the right of increasing the number of lamps in each section by any amount up to 30 per cent. of the original number on the basis of such tender.

The installation shall be completed by the 9th of April, from which date the penalties defined in Clause 24 shall be enforced. After the 9th day of April, and until one week previous to the opening of the Exhibition, the contractor shall light such lamps as may be ordered by the superintendent, at any hour between six a.m. and midnight, during the week preceding the opening at any hour whatever, and from the opening day till the Exhibition closes at any time while the Exhibition is open, and until all visitors shall have left.

The tenders shall be based on the assumption of 500 hours' lighting between April 9 and October 31; but a separate clause shall be added stating the amount to be charged per hour for every hour beyond 500 between these dates, and a further clause stating the amount to be charged for every hour after October 31, on the understanding that if the Exhibition is kept open after October 31 the lights will be required for at least six hours per day.

The superintendent of the Exhibition shall give each day to the contractor or his representative a written order, stating the hours during which the lights are to be running, and these orders shall be accepted as the basis on which the number of hours of lighting shall be calculated.

Payments shall be made monthly to the extent of 75 per cent. of the amount due, and the remainder shall be paid in full within one month after the closing of the Exhibition.

The contractor shall, when requested by the superintendent with the authority of the executive, remove from the work permanently any foreman, workman, or attendant who may be considered by the executive to be incompent or insubordinate, and the contractor shall forthwith substitute other foreman, workman, or attendant in his stead.

The contractor shall be liable for any damage to any part of the buildings, or exhibits, or accessories thereto, or to any person or animal, and shall be liable for any damage whatever, whether by trespass or otherwise.

No extras shall be allowed, or paid for, unless the contractor can produce an official order for the same, signed by the superintendent of the Exhibition, and describing each particular item.

Each tender shall contain a description of all lamps proposed to be employed, stating the E.M.F. and current required by each, and the contractor shall be responsible for providing the full current to each lamp. If the current or E.M.F. supplied is allowed to fall short by more than 5 per cent. of the number of amperes or volts specified the lamps shall be deemed to be unlighted, and the contractor shall become liable for the penalty defined in Clause 24.

The executive shall be responsible for providing the power stipulated in the contract. If the contractor require more power than that agreed upon for the number of lamps the contractor shall pay to the executive the sum of 3d. per hour for each brake horse-power so required at the counter-shafts, and the executive shall have power to deduct such charge from the monthly payments to the contractor.

For every lamp not alight when required, a penalty may be inflicted according to the following scale, and the amount of such penalties shall be deducted from time to time from the monthly sums payable to such contractor:—(*a*) For a single arc lamp, for every half-hour or portion of half-an-hour, the sum of one shilling. (*b*) If more than one arc lamp in the same section is extinct at such time as it should be alight the penalty shall be reckoned as for a single lamp, but shall be proportional to the square of the number of lamps extinct at the same time. Thus for two lamps extinct it shall be 4s. for every half-hour or portion of half an hour, for three lamps 9s., and so on. (c) For every incandescent lamp extinct for more than one evening the penalty shall be 1s. per evening for a

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nominal 20-candle lamp, 2s. for every 50-candle lamp. When more than fourteen 20 candle-power lamps or five 50 candle-power lamps are extinct in the same section, the penalty shall be calculated as for arc lamps, every group of 300 candle-power being reckoned as equivalent to one arc lamp. Single incandescent lamps of 300 candle-power or upwards shall be regarded for the purposes of this clause as equivalent to arc lamps, unless extinct through the breaking of a filament and replaced within reasonable time.

If the penalty inflicted under the last clause amount during any week to more than £40, or the contractor become bankrupt, the executive shall have the right to annul the contract, and to cause the plant belonging to such defaulting contractor to be removed, but shall retain a lien upon such plant to the extent of any penalties and expenses which may be incurred through the default. Penalties and expenses may be deducted from any money due under the contract, or may be recovered from the contractor as and for liquidated and ascertained damages.

Any question relating to the interpretation of these conditions shall be referred to the chairman of the Lighting Committee, whose decision shall be final. The sections for which tenders are now invited are the following:—(A) For 32 arc lamps, each absorbing 350 watts, for the central span of the north court. (B) For 36 arc lamps, each absorbing 500 watts, and one arc lamp absorbing 750 watts, in the entrance hall and side spans of the north court. (C) For 35 arc lamps, each absorbing 500 watts in the east, south, and west courts. (D) For 8 arc lamps in engine shed, 8 in dining room, 8 in concert room, 12 in central garden, carried on 4 masts, each 35ft. in height, in all 36 arc lamps, each absorbing 500 watts (and four masts). (E) For 100 incandescent lamps in verandah, 60 incandescent lamps around band stand, 120 incandescent lamps on and above the entrance porch outside the building, and 40 incandescent lamps in the offices at the entrance, in all 320 incandescent lamps of 20 candlepower, and one group of incandescent lamps in the band stand of 300 candle-power in the aggregate. (F) For 114 incandescent lamps of 50 candle-power in the annexe adjoining the verandah, and four groups of lamps, of not less than 300 candle-power each in the corner refreshment rooms. (G) For 127 incandescent lamps, of 50 candle-power each, in the annexe surrounding the building. (H) For 400 incandescent lamps, of 20 candle-power, in the art gallery. In this gallery special supports for the lamps will be provided by the executive, but the usual holders and the wiring must be provided by the contractor. (K) For 55 incandescent lamps, of 20 candle-power, in the coal mine. The mine will be about 150 yards in length, and proceed northwards from the middle of the north end of the Exhibition.

The plans of the engine room, dining rooms, concert room, and art gallery are not yet complete. The art gallery will consist of two spans, each of 30ft. in width, and about 140ft. in length. The lamps will be placed at intervals of about 18in. on a frame provided by the executive, and furnished with suitable supports for the lamp holders.

NOTE.—By the term 20-candle lamp is to be understood what is now generally called a 16-candle lamp. A number of additional lamps will be required for the grounds (which will comprise about 14 acres) and various detached buildings placed therein, but these will form the subject of future contracts.

SOME EXPERIMENTS ON SECONDARY CELLS.

BY JAMES SWINBURNE.

(Continued from page 154.)

Carbon for Peroxide Plates.—The practice of making peroxide plates of carbon does not seem to be quite abandoned even yet. Carbon is more easily oxidised than is popularly supposed; in fact, Brodie's process for disintegrating graphite depends on the action of an oxidising agent. We tried some Faure plates with carbon in dilute sulphuric acid and in a solution of zinc sulphate. In both cases the carbon was attacked. After standing for some days the peroxide plates seemed quite good, and the peroxide appeared to stick well to the carbon and to form good coatings. On examination, however, it was found that the carbon under the peroxide was converted into a soft black pulp. Carbon was tried as anode in various solutions, such as sodium carbonate, sodium phosphate, phosphoric acid, dilute sulphuric acid, potassium fluoride, potassium sulphide, hydrochloric acid, liver of potassium, potassium chromate, ferri-cyanide, ferro-cyanide, permanganate, borax, potassium tungstate, potassium hydrate, sodium chloride, &c. In all cases where oxygen would otherwise have to be evolved the carbon was attacked, but when a current could pass by evolving chlorine the carbon was not attacked. As peroxide of lead acts on a chloride in an acid solution, carbon is evidently useless for peroxide plates. It may do admirably for bleaching or evolving chlorine or making hypochlorites. The same conclusions were arrived at by Bartoli. Biscuit, or unglazed porcelain, impregnated with carbon deposited from hydrocarbon by heat, was tried. It split into small pieces. It is odd that none of the sufferers from primary battery disease have used this material for porous pots, as many of them have the idea that a carbon porous pot somehow reduces the resistance of the cell.

As no metals were available as indestructible supports for the oxidised plate in dilute sulphuric acid, and as carbon also appeared useless, the next thing was to try to make the supports of peroxide itself. Peroxide made by oxidising coatings made originally from litharge or red lead was not hard enough to make good supports; but the peroxide deposited by electrolysis of an alkaline solution of a lead salt was very much harder. The best way seemed to be to make a paste of litharge and caustic soda, and to attach it to the lead plate and make it the anode in a solution of caustic soda. When the whole of the litharge was oxidised the lead plate was removed. The resulting peroxide was very hard, and seemed quite impervious; when a bit was used as a plate in a cell, and the cell discharged, it ran down at once, the peroxide being covered by a very thin film of lead sulphate. The surface seemed to be the only part in contact with the acid. It would be a matter of great practical difficulty to make cells with peroxide supports commercially. It would be interesting to know how this form of peroxide compares with Mr. FitzGerald's *lithanode* in point of hardness and durability. The peroxide from a solution of nitrate and tartrate of lead looks very dense and hard, but it comes in the form of scales resembling iodine. Before leaving the subject of lead plates some experiments on lead sulphate must be described. It was supposed at one time that lead sulphate could not be reduced in dilute acid. Sir William Thomson had made experiments with it, and had found it would not reduce. We made a cell with platinum plates and precipitated lead sulphate in dilute sulphuric acid; it was charged for five weeks, and at the end of that time the sulphate on one was completely oxidised, but on the other it was only reduced here and there in spots. A similar cell was then started with a little litharge mixed with the sulphate; the sulphate then reduced perfectly. This is a result of some importance. The reduction of sulphate seems to be purely a question of good contact. In many cells which gave very small outputs the reduced plates were found to be in fault. The slightest film of thoroughly-formed sulphate acts as a perfect insulator. It is a good plan to keep a small cell always ready with both plates fully charged; then, when a cell under test runs down, each plate is separately tried with a proof plate, and it is then found which of the plates has failed. The film of sulphate formed on a piece of lead reduces all right, but as sulphate of lead is very bulky its formation seems to cause buckling about and resulting bad contacts. To see how great the swelling due to the formation of sulphate of lead is, the specific gravities were taken, and the following are the resulting figures:—

100 volumes of lead form—

Peroxide of lead	160
Red lead	143
Litharge	151
Lead sulphate	297

This shows that lead converted into sulphate swells into three times its original bulk, and that peroxide on becoming sulphate is doubled in volume; this at once shows why coatings tumble off plates. To see how much of the active material in a cell is really used, several plates were made up with weighed quantities of lead oxides. One of these was a little Sellon plate, made of a piece of a large plate filled with minium or litharge; others were Faure plates. After charging, the plates were short-circuited through copper voltameters. The maximum output was from 5 to 7 per cent. of that calculated.

Many attempts were made to make coatings that would stick well. Collodion was of no use; litharge and sugar did not make good coating; sodium silicate mixed with the litharge before applying was useless. Litharge and glycerine form a very useful cement known as engineers' cement. Though the coating was very easy to manage, there seemed to be no permanent advantage in using glycerine. This coating has been patented. In those days it was usual to wrap plates in flannel to keep the coating on. The flannel generally went to pieces very soon; it appeared, however, that this is not due to the action of the acid, but to oxidation through contact with the peroxide. Asbestos paper is too weak to be of any use. Cotton or linen is soon destroyed by acid, but resist strong alkali longer; while flannel resists acid, but is attacked by alkali. Pyroxylin is easily attacked by alkali, not easily by acid. Tribe proposed to use pyroxylin for supporting plates. Xylonite has also been tried for me more recently by Mr. Cathcart, then my assistant. It is much the same as celluloid, being made of pyroxylin and nitrobenzole, camphor, or some such solvent. This will stand being boiled in moderately strong sulphuric acid for a long time, and should be very useful in battery work. Flannel was soaked in collodion, with the idea that the fibres might thus be protected, but they were not. Flannel was also soaked in sodium silicate and attacked with sulphuric acid; it succumbed.

Strength of Acid.—It was usual to use acid of a strength of 1 to 10. This probably arises from that being the strength in vogue for Daniell batteries.

The strength of acid was also not considered, because the action of secondary batteries was for some unaccountable reason supposed to be due to the formation of litharge on both plates. I am afraid Dr. Lodge was much to blame for perpetuating this error. Another absurd theory was that the action is due to occluded hydrogen in the reduced plate. It has been said that the study of secondary batteries belongs to chemists, not to electricians; but it is strange that when chemists have to deal with electrolysis they seem to forget their chemistry, or to imagine that the laws of chemistry no longer hold good. As the action of the cell depends on the formation of lead sulphate, it is clearly an advantage to have as much acid as possible available in the coatings.

On looking into Gladstone and Tribe's book on secondary batteries they are found to state that the action on the peroxide plate is as follows:—The peroxide is reduced to monoxide, and the sulphuric acid then combines with this to form lead sulphate and water. If this were the case the energy due to the combination of the lead with the sulphion would be entirely converted into heat, not into electrical energy. Chemists have a lot of time-honoured ideas which do not at all fit the facts of electrolysis. One is that salts are formed by the combination of an acid and an alkali.

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In old days people spoke of the sulphate of the protoxide of lead and so forth, and lead sulphate was represented as PbO,SO_3 when it was understood that the water was eliminated. Even now chemists seem to assume, without foundation, that a metal cannot form a salt without passing through the intermediate state of oxide, though really an oxide is itself just as much a salt as a nitrate or sulphate. If electrolysis proves anything at all it is that a salt is made up of an electro-negative and an electro-positive radicle, not of a base and an acid with some water eliminated. The action of an acid and an alkali is simply the exchange of radicles, the most electro-negative radicle combining with the most electro-positive, making a salt in which neither preponderates, or, as it is called, a neutral salt.

If the coatings have only weak acid, it may be all absorbed when the cell is discharged a little, and the electromotive force will fall, and there will be a tendency to the formation of basic salts in the coatings; but, on the other hand, if the acid is made stronger, it may be decomposed without electrolysis, as when peroxide of lead evolves oxygen and forms lead sulphate, or as when spongy lead evolves hydrogen and forms lead sulphate. In the case of spongy lead there may or may not be electrolysis. If the acid is so strong that the lead decomposes it directly, there is no local action; but if there be some more electro-negative metal, such as, say, antimony, in contact with it to evolve the hydrogen, there is electrolysis.

Another universally accepted theory without any foundation is that all electrolysis is due to the action of nascent hydrogen or oxygen. In old times when someone saw bubbles coming off zinc in an acid solution of, say, an iron persalt, and found the persalt was reduced to a protosalt, he naturally supposed the gas was the cause of the action. But there is no reason to suppose the hydrogen has anything to do with it. It takes a certain electromotive force to give off the hydrogen, and a certain less electromotive force to reduce the persalt. If the available electromotive force is between these values, the persalt will be reduced without any hydrogen being formed. To suppose that hydrogen is first formed, and that the thing then changes its mind and does an easier chemical action, is unphilosophical. The combination of the zinc with the available negative radicle will go on, the action being made possible by the reduction of the persalt when present, and by evolution of gas when no persalt is present at that spot. The nascent gas idea is like saying that when one goes up to the first floor one goes to the roof and tumbles down again to the first floor.

Still further reduction takes place in thousands of ordinary chemical actions where no hydrogen is present, as when carbon monoxide is passed over hot litharge. Again, electrolysis takes place quite well without hydrogen or oxygen being present, as when a fused metallic chloride is electrolysed.

Another unfounded theory is that it is the water that does all the conducting, and that it is first decomposed, the other action being secondary. Pure water does not conduct, neither does pure sulphuric acid, but the mixture does; how, then, is it inferred that the water only of the mixture conducts? No doubt the only way to study electrolysis is to divest it of all pre-conceived theories that have no logical foundations, and to study thermo-chemistry.

The best strength of acid was not determined by us, and it no doubt depends on the purity of the lead, and of all the compounds forming the coatings, and of the acid itself. It also depends on the way the cells are to be used. If the acid is strong, both oxygen and hydrogen will be given off slowly, even during several weeks. As the idea of using secondary batteries as magazines for storing energy for long periods is being given up, this slow decomposition is of little importance; but there is another point—that is, that sulphuric acid which is not very dilute separates into two strata of different specific gravities. Before leaving the subject of lead cells it may be as well to mention that the troublesome spray that comes during charging may be prevented by floating paraffin on the top of the acid. The spray not only tarnishes, rusts, or destroys everything near, but is the cause of all sorts of ground leaks. The paraffin prevents the acid from creeping; in fact, it creeps itself, and acts as an insulator.

Alkaline Cells.—It is well known that iron is very electro-negative in an alkaline solution; but such solutions as that of caustic soda or potash are not available, because nearly all salts of lead are soluble in them. It was therefore attempted to make cells with iron supports in an alkaline solution of some salt whose acid radicle would not attack iron, and would precipitate lead salts. Iron in solutions of potassium cyanide, ferrocyanide, and ferri-cyanide was attacked; the ferro-cyanide or yellow prussiate of potash plate was least eaten. Even such salts as sodium sulphate dissolve some lead sulphate. This property is important in connection with ordinary secondary batteries. A little sodium sulphate mixed with the acid may tend to make the sulphate of lead more easily reduced; as, when all the sulphate is reduced that is in contact with the support, hydrogen is evolved, and caustic soda is formed in the immediate neighbourhood of the plate, and can dissolve the sulphate, the lead being then precipitated as spongy lead. The spongy lead can thus make contact with the sulphate. Magnesium sulphate has been recommended as a solution, but it is difficult to see why. Zinc sulphate might be good. Alkaline sulphides of course attack iron.

Iron plates with coatings of white lead in solutions of sodium carbonate: these oxidised and reduced very well, but the iron seemed to be slightly attacked. On testing the peroxide traces of iron were found. Thinking the corrosion of the plate was perhaps due to impurities in the carbonate, such as sulphate, experiments were tried with the purified salts. The iron seemed to be in a sort of unstable state. Sometimes it would remain quite clear and bright in contact with the peroxide, and with bubbles of oxygen evolving from its surface; but suddenly a green spot would appear, due, no doubt, to the formation of carbonate of iron, and this spot would extend and cover the whole plate. The best results were got with bicarbonate of soda.

Nickel was tried in the same solutions. It behaved in the same way, though it was not quite so easily attacked. The carbonate was lighter in colour, being apple green. Iron plates with borax solution: green discoloration. Iron plate with caustic, potash, and tannin: iron eaten. Some cells were tried with iron plates and ammonia; but as it is probable that nitric acid would soon be formed in them they were abandoned. The alkaline cells gave 1·7 volt. The measurements were taken roughly. A calibrated tangent galvanometer was used as a voltmeter; for measuring currents a low resistance was made up consisting of a lot of wires put in parallel, their resistance having been measured in series. Ammonia sometimes gave a brown deposit with iron plates.

As it seemed hopeless to get iron to stand without being attacked, various methods of protecting it were tried. Iron gauze was coated with peroxide by making it the anode in a solution of litharge in caustic. When this solution is electrolysed clouds of litharge are evolved close to the plate. This is very curious, for if the solution is plumbite of lead the electro-negative radicle would be PbO_2, not PbO; such a salt being presumably $Na_2 PbO_2$. It is very probable that this deposit was not due to electrolysis; but to the solution becoming more alkaline at one side than the other, thus depositing the litharge. Peroxide of lead deposited from solution of lithage in caustic is too dense to be used as an active coating; it was proposed to use it to protect the iron, and to have then applied a coat of porous peroxide such as is used in acid cells. The peroxide was never satisfactory. To make up for the imperviousness of the peroxide, red lead and water were rubbed into the pile of velvet; the velvet was placed with its face against the iron plate, and the coating was oxidised in an alkaline solution. The velvet was then dissolved out by strong alkali, so as to leave a coating with a very large surface. The plate, however, had very small capacity. Electro-gilding the iron was then resorted to. It is a little difficult to gild iron, as the gold does not stick well. After each coat of gold the iron was heated to make the gold sink in. The gilded plates did not answer well. The Bower-Barff process for protecting iron from rust was tried, by getting an ornamental railing top and making it the anode in a cell. The black oxide did not prove to be a good enough protection. The strange thing about the corrosion of iron in alkaline solutions is that it does not take place if there is no coating. A piece of sheet iron may be used as anode in the solution of carbonate or bicarbonate of soda without being the least corroded; but if a coating of, say, white lead is applied, green spots appear at once, but only under the white lead; the back of the plate remains quite clear. Oddly enough, sheet tin is not easily attacked by an alkaline solution. Sometimes it turns black, or the surface, which consists of an alloy composed chiefly of tin, peels off in black scales. Sheet tin behaved much as iron or nickel; that is to say, it behaved very well till a coating was put on, and then it was corroded. There is a very curious alloy of iron and tin. If iron and tin are melted together, the resulting alloy separates into two portions; one is approximately Fe Sn, and the other consists chiefly of tin, and has a low melting point. The alloy Fe Sn solidifies at a red heat. It was too unmanageable to be of much use for batteries, and it was no better than sheet tin; but it was so hard that a straw-hardened cold chisel even would not cut it, but broke in pieces, while a softer chisel turned up at the edge. This alloy might be useful in commerce. The writer has since tried to make more of this alloy for some experiments on persistent magnetism, but has never succeeded in making it so hard again.

Iron without a coating is not attacked in such solutions as potassium bichromate, or permanganate. At first sight this seems strange, but it must be remembered that such salts owe their corrosive properties, especially when acting on organic bodies, not to the strength of their acid radicles, but to the electro-positiveness of chromium and manganese, which makes them combine energetically with an acid radicle to form chromium or manganese salts. Thus potassium bichromate or chromic acid in the presence of sulphuric acid is a very powerful oxidising agent, but if there is no acid present to form a chromium salt it is no longer energetic. Iron in alkaline solutions is very convenient for adjustable water resistances.

We worked at iron cells with some tenacity, because we seemed to be very near success; and if we could make a peroxide plate with iron without local action, the negative might be of zinc, as this combination gives a high electromotive force.

Cells with Zinc.—Evidently cells with zinc could not be used in most acid solutions, as so many of its salts are soluble. Secondary batteries with zinc plates have often been brought out; but as the zinc dissolved on discharging is not deposited on the same part of the plate on charging, these cells cannot well be used very often. M. Reyneir has lately worked at cells with zinc in sulphuric acid and Planté peroxide plates. He does not say how he proposes to get over the difficulty of the zinc being deposited in the wrong place. He says that the deposited zinc is so pure that there is very little local action. His cells give 2·37 volts.

We tried plates with reduced zinc coatings in alkaline solutions that do not dissolve zinc, such as sodium carbonate and sodium bicarbonate. The coatings were made of oxide or carbonate of zinc. The chief trouble was the proper reduction of the zinc. These salts of zinc behave very much like lead sulphate—that is to say, they are very bulky—and the coatings form hard white cakes which are not in good contact with the support. When the zinc is eventually reduced it is very soft and loose. Very likely we made a mistake in reducing coatings of oxide or carbonate of zinc, instead of forming the coating out of the solid plate by attacking it when used as anode. The object aimed at was the use of iron for the support of lead peroxide in the other element; but as we did not get iron to work satisfactorily, we did not do very much with the zinc.

Primary Cells.—A few experiments were made, but they are not worth recording. Lately, however, the writer saw a note in *The Electrician* to

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the effect that a French *savant* had used agar-agar jelly in a Leclanché cell. It seemed possible that the use of this might avoid the necessity for a porous pot in a two-fluid cell, the idea being that to make up a cell one might take a zinc plate, place on it a wad of zinc sulphate jelly, place on that a wad of copper sulphate jelly, and cover it with a copper plate. Zinc and copper jellies are easily made, but the drawback is the rapid diffusion of the copper salt. Some cells were made with zinc filings suspended in the zinc jelly, so that any wandering copper salt might be caught before it reached the zinc plate. As rapid diffusion is always the result of a low-resistance porous cell, it seems useless to try to make a low-resistance two-fluid cell unless some colloïd oxidising agent can be found. Some of the solutions of iron were found by Graham to be colloïdal ; perhaps something might be done with them.

A bichromate jelly cell was tried, but it was also a failure. The same thing was noticed as in the case of flannel and cotton. Bichromate jelly with no acid keeps for any length of time ; and sulphuric acid jelly can also be made ; but the jelly dissolves at once if both acid and bichromate are present. The same things happens with potassium permanganate.

Agar-agar is a fucus or seaweed. It has, if the writer is not mistaken, the same composition as starch. It has a very high gelatinising power—about ten times that of gelatine. It is probably used for sizing paper or calico, or for cooking. Mr. Stanford, of Glasgow, is an authority on the uses of seaweeds.

Gelatine was tried, but it was liable to go bad, and was at once attacked by oxidising agents.

Probably gelatinous silica may do, but the writer has not yet made enough experiments to say. A low-resistance bichromate cell in which the bichromate had not access to the zinc would be very useful where a large power is occasionally required, as in the laboratory.

Miscellaneous.—While various cells were being charged or discharged there were often odd quarters of hours to spare. These were spent in trying different experiments not connected directly with secondary cells.

White Lead.—It was attempted to make white lead electrolytically. The present method of making white lead, which is felicitously termed the "Dutch process," is slow and barbarous, and exceedingly unhealthy. The women who are continually among the white lead absorb the lead through their skins, or perhaps swallow it little by little, and are apt to suffer from lead poisoning. Messrs. Cookson and Co. have probably the best sanitary regulations and arrangements in the world ; but even then the Dutch process is very dangerous.

To make white lead electrolytically, plates of lead were made anodes in solutions of carbonate or bicarbonate of soda, with very small currents In many cases white deposits were obtained, but in no case was any quantity obtained. If the current was increased the plate was soon coated with a brown compound. To imitate the action of the basic acetate a little acetic acid was added to some of the solutions. In some cases a very curious phenomenon was seen. Long white columns like small candle drippings started about the middle of the plate, and grew down to the bottom of the beaker. The plates were about three inches from the bottom.

Experiments were tried with lead plates and solutions of salt with a view of making white oxychloride of lead. The plates were, of course, easily attacked, but if the current was very small the coating formed very slowly, and appeared crystalline, and if the current was increased the coating turned brown.

Sodium Chlorate.—Potassium chlorate is very largely used for making English matches, and in dyeing. It is probably used instead of sodium chlorate because it can easily be separated from chloride by crystallisation. To make sodium chlorate, solution of salt was electrolysed. This gives off chlorine at the anode, and various salts, such as sodium hypochlorite, are formed. If sodium hypochlorite is boiled it gives chlorate and chloride. We prepared a mixture of sodium chloride and chlorate, but the percentage of chlorate was too small for the process to be valuable.

Aniline Dyes.—There may be a large field for the application of electrolysis in the aniline industry. A cell was tried with aniline, but it would not conduct. A cell was tried with phenol, but it would not conduct. Potassium hydrate was therefore dissolved in the phenol to make it conduct. A black compound was formed at the anode.

These last experiments are not brought forward as of any value, but they are instances of applications of the dynamo to very different industries. Now that we have the dynamo as a commercial machine, we seem to be resting content with one very small use for it. We use it almost entirely for the electric light. Though it is quite well understood that power can easily be transmitted electrically, the use of motors can hardly be said to be pushed at all. Engineers have only to be shown motors at work to see what beautiful, smooth, and silent-running things they are, and they will be applied in thousands of instances. The dynamo is now being introduced for the treatment of argentiferous copper ; but this is a comparatively small industry. The electro-plating fraternity are a very peculiar people. Though constantly using it they seem to know as little about electricity as medical men. Before electricians can meet them on common ground they must give up talking of the strength of the quantity of current from seventeen Smee cells.

But above all these uses the electrical engineer can supply the chemist with a most efficient and convenient oxidising or reducing agent; unfortunately, however, the electrical engineer does not know what the chemist wants, and the chemist does not know what the electrician can give him.

Every week more young men begin studying to qualify as electrical engineers. Like pins, it is unknown what becomes of them. Would it not pay some of those who are sharp and inventive to take up the study of electro-metallurgy systematically, and to explore that almost untrodden field of the application of the dynamo ?

DYNAMO-ELECTRIC MACHINERY.

By J. Hopkinson, M.A., D.Sc., F.R.S., and E. Hopkinson, M.A., D.Sc.

(Concluded from page 88.)

Appendix.—Added Aug. 17.

Since the reading of the present communication experiments have been tried on machines having armatures wound on the plan of Gramme and with differently arranged magnets ; the experiments were carried out in a closely similar manner to that already described.

Description of Machines.—In these machines [we have not given the illustrations of these machines, the description being sufficient to show how they differ from those illustrated in the preceding part of the paper, *vide* page 42, Nov. 19.] the magnetic circuit is divided. The pole-pieces are of cast iron, and are placed above and below the armature, and are extended laterally. The magnet cores are of wrought iron of circular section and fit into the extensions of the cast-iron pole-pieces, so that the area of contact of the cast iron is greater than the area of section of the magnet. The magnetising coils consist of 2,196 convolutions on each limb of copper wire, No. 17, B. W. G. in No. 1 machine, and 2,232 convolutions in No. 2 machine. The pole-pieces are bored to receive the armature leaving a gap on either side subtending an angle of 41° at the axis.

The bearings are carried upon an extension of the lower pole-piece. The following table gives the principal dimensions of the magnets in No. 1 machine :—

	Cms.
Length of magnet limbs between pole-pieces	26·0
Diameter of magnet limb	8·6
Bore of fields	25·7
Width of pole-piece parallel to the shaft	24·1
Width of gap between poles	8·6

The armature is built up of plates as in the machine already described, and is carried from the shaft by a brass frame, between the arms of which the wires pass.

The principal dimensions are as follows :—

	Cms.
Diameter of core	24·1
Diameter of hole through core	14·0
Length of core over end plates	24·1

The core is wound on Gramme's principle, with 160 convolutions, each consisting of a single wire, No. 10, B. W. G., the wire lying on the outside of the armature in a single layer. The commutator has forty bars. This dynamo is compound wound, and is intended for a normal output of 105 volts 130 amperes, at a speed of 1,050 revolutions per minute. The resistance of the armature is 0·047 ohm, and of the magnet shunt coils 53·7 ohms. There is here no yoke, and consequently A_4 and l_4 do not appear in the equation.

It is necessary to bear in mind that the magnetising force is that due to the convolutions on one limb, and that the areas are the sums of the areas of the two limbs. In calculating induction from E.M.F. it is also necessary to remember that two convolutions in a Gramme count as one in a Hefner-Alteneck armature.

A_1 ;—the section of the core is 245 sq. cms., allowances for insulation reduce this to 220·5 sq. cms.

l_1 ;—this is assumed to be 10 cms., but it will be seen that an error in this value has a much more marked effect on the characteristic in this machine than in the other.

A_2 ;—the angle subtended by the bored face of the pole-pieces is 139°, the mean of the radii of the pole-pieces and the core is 12·45 cms. Hence the area of 139° of the cylinder of this radius is 768·3 sq. cms. ; add to this a fringe of a width 0·8 of the distance from core to pole-pieces as already found necessary for the other machine, and we have 839·5 sq. cms. as the value of A_2.

l_2 is 0·8 cm.

A_3 is 365 sq. cms. (*i.e.*, the area of two magnet cores).

l_3 is 26·0 cms.

A_5 is taken to be 955 sq. cms., viz., double the smallest section of the pole-piece.

l_5 is a very uncertain quantity ; it is assumed to be 15 cms.

The expression already used requires slight modification. Inasmuch as the pole-pieces are of cast iron a different function must be used. Different constants for waste field must be used for the field, the pole-pieces, and the magnet core. We write

$$4 \pi n c = l_1 f\left(\frac{I}{A_1}\right) + 2 l_2 \frac{\nu_2 I}{A_2} + l_3 f\left(\frac{\nu_3 I}{A_3}\right) + 2 l_5 f'\left(\frac{\nu_5 I}{A_5}\right)$$

the function f' is taken from Hopkinson, *Phil. Trans.*, Vol. 176 (1885), p. 455, Plate 52. ν_2, ν_3, and ν_5 were determined by experiment as described below ; their values are

$$\nu_2 = 1{\cdot}05$$
$$\nu_3 = 1{\cdot}18$$
$$\nu_5 = 1{\cdot}49$$

Comparing the curves on Diagram A (p. 40 *ante*) with those on Diagram C, on following page, the most notable difference is that in the latter the armature core is more intensely magnetised than the magnet cores. No published experiments exist giving the magnetising force required to pro-

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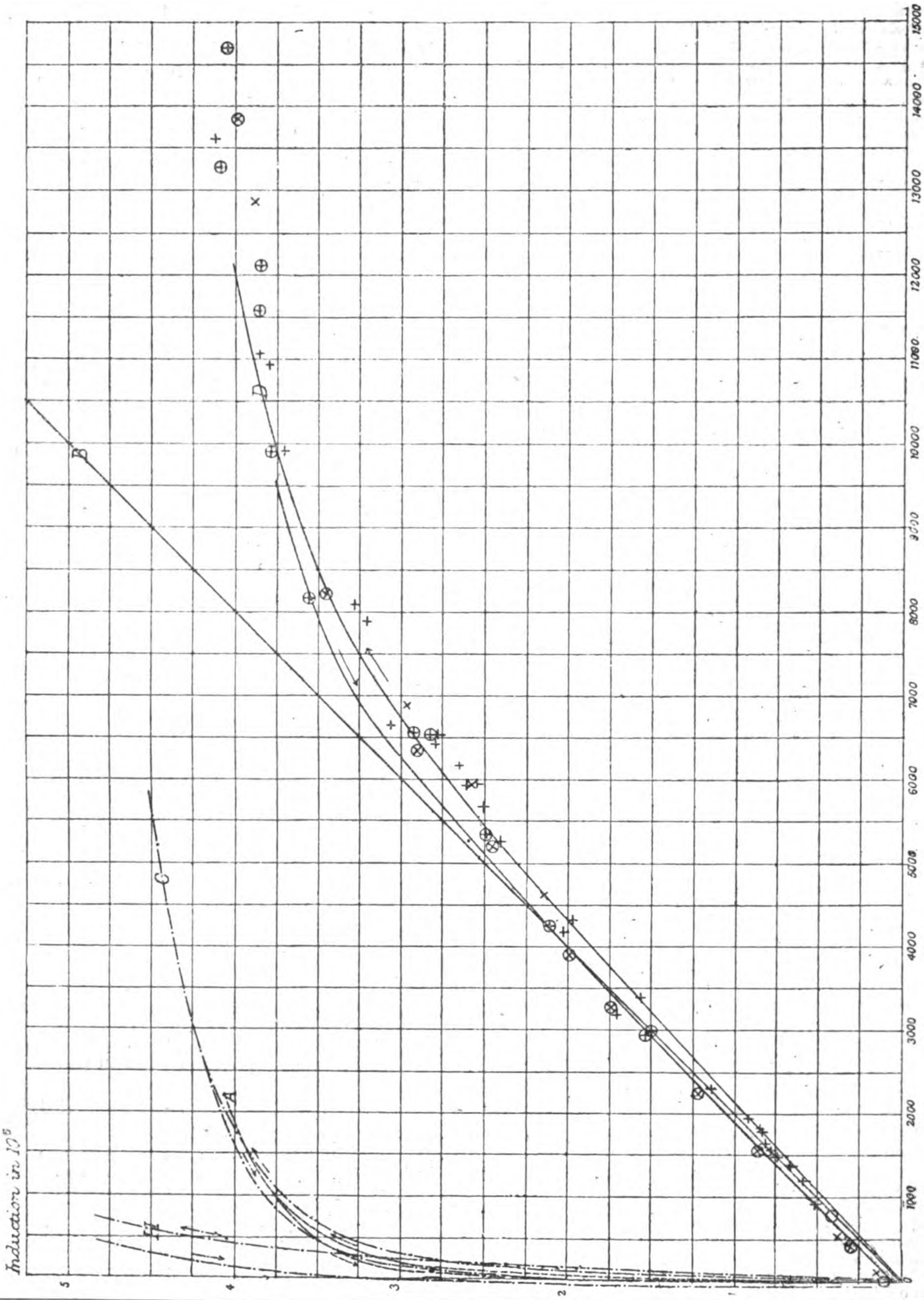

DIAGRAM C.

Synthesis of characteristic curve of machine with gramme armature. Observed results—No. 1 Machine + ascending (+) descending; No. 2 Machine × ascending (×) descending. A Armature. B Air space. C Magnets. D Deduced curve. H Pole pieces.

duce the induction here observed in the armature core, amounting to a maximum of 20,000 sq. cm. We might, however, make use of such experiments as the present to construct roughly the curve of magnetisation of the material; thus we find that with this particular sample of iron a force of 740 per cm. is required to produce induction 20,000 per sq. cm.; this conclusion must be regarded as liable to considerable uncertainty.

The observations on the two machines are plotted together, but are distinguished from each other as indicated. They are, unfortunately, less accurate than those of Diagram A *ante*, and are given here merely as illustrating the method of synthesis.

Experiments to determine ν_2, ν_3, *and* ν_5.—The method was essentially the same as is previously described, and was only applied to No. 1 machine. Referring to Fig. 7, a wire A A was taken four times round the middle of one limb of the magnet, a known current was suddenly passed round the magnets, the elongation of the reflecting galvanometerer was observed; it was found to be 214 scale divisions, giving 107 as the induction through the two magnet limbs in terms of an arbitrary unit. The coil was moved to the top of the limb as at B B—the elongation was reduced to 206 or 103 for the two limbs. We take the mean induction in the magnet to be 105. A wire was taken three times round the whole armature in a horizontal plane as at C C; the elongation observed was 222 divisions or 74 in terms of the same units. A wire was taken four times round one half of the armature as at D, D; the elongation was 141, or induction in the iron of the armature 70·5, whence we have

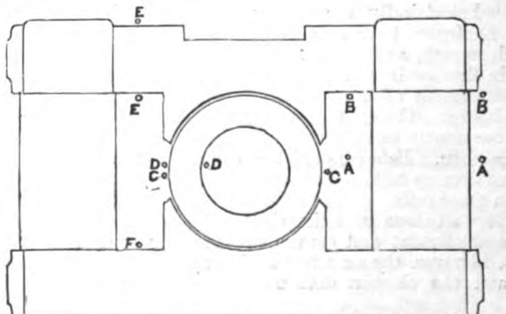

FIG. 7.

$$\nu_2 = \frac{74}{70 \cdot 5} = 1 \cdot 05.$$

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It may be well to recall here that ν_2 is essentially dependent on the intensity of the field; strictly the line B on Diagram C should not be straight but slightly curved.

Four coils were taken round the upper pole-piece at E E; the elongation was 159, giving 79·5 on the two sides. Coils at F F give a higher result, 87·5, owing to the lines of induction which pass round by the bearings of the machine, and across to the upper ends of the magnets—ν_2 is taken to be

$$\frac{83 \cdot 5}{70 \cdot 5} = 1 \cdot 18.$$

The method and instruments were those already described, excepting that the current was measured by a Thomson's graded galvanometer, which had been standardised against a Clark's cell in the position and at the time when used. The resistance of leading wires and galvanometer was 0·034 ohm, the series coils introduced for compounding the machines were also brought into use, and the losses due to their resistance find a place in columns XII. and XIII. of the following Table III., in which column I. is lead of brushes of the dynamo, positive for the generator, negative for the motor; column II., revolutions per minute; column III., deflection of spring in grammes; column IV., watts by dynamometer; column V., volts at terminals of generator; column VI., amperes in external circuit; column VII., rheostat resistance; column VIII., watts in generator armature; column IX., watts in motor armature; column X., watts in generator shunt magnet coils; column XI., watts in motor shunt: column XII., watts in generator series magnet coils; column XIII., watts in motor series; column XIV., watts in external resistances; column XV., total electrical power of generator; column XVI., half the sum of losses unaccounted for; column XVII., total mechanical power applied to generator.

Table III.

No. of experiment.	I. Degs.	II. Revs.	III. Grms.	IV. Watts.	V. Volts.	VI. Amps.	VII. Ohms.	VIII. Watts	XI. Watts.
1	17·5°	1098	7711	4419	100·1	139·0	∞ty	955	895
2	5°	1094	2722	1554	103·8	41·2	18·8	105	78
3*	0°	1144	1814	1083	104·7	7·85	0	11	3

No. of experiments.	X. Watts.	XI. Watts.	XII. Watts.	XIII. Watts.	XIV. Watts.	XV. Watts	XVI. Watts.	XVII. Watts.
1	372	0	497	464	657	16,395	289	16,684
2	400	138	55	41	148	5,015	294	5.309
3*	395	409	6	1	2	1,637	128	1,765

* In this experiment the direction of the current had become reversed, and No. 2 machine was generator.

Table IV.

No. of experiment.	Generator armature.	Generator shunt coils.	Generator series coils.	Other losses.	Effici'ncy of generator	Effici'ncy of motor.	Effici'ncy of double conversion.
1	5·8	2·2	3·0	1·9	87·1	89·0	77·5
2	2·0	7·5	1·0	5·5	84·0	92·0	77·7

Table IV. gives the losses and efficiencies as percentages in exactly the same way as in Table II., excepting that another column is introduced for the loss in the series coils of the magnets of the generator.

The core of the armature contains about 6,500 cub. cms. of iron. Hence energy of magnetising and demagnetising when the speed = 1,100 revolutions per minute $= 6{,}500 \times \frac{1{,}100}{60} \times 13{,}356$ in ergs per second = 159 watts.

In conclusion, we desire to express our indebtedness to Messrs. Mather and Platt, by whom the machines we have used were manufactured, and who, in placing the same at our disposal, together with all facilities for carrying out our experiments at their Salford Iron Works, have enabled us to put theory to the test of experiment on an engineering scale.

THE TESTING OF DYNAMOS AND MOTORS.

At the City and Guilds of London Institute, Exhibition-road, during the months of February and March, Prof. Ayrton will give a course of seven practical demonstrations in the dynamo rooms and laboratories of the Institution. Each demonstration will be given twice, once on the Friday, at 5 p.m., and again on the following Wednesday, at 5 p.m., in order that all who attend the course may take part in the experiments. After Ash Wednesday, on which day the college will be closed, the same demonstration will be given on the Wednesday and Friday of the same week. In addition to making the measurements referred to in this syllabus, and describing in detail the principles of each experiment, Prof. Ayrton and his assistants will, *before* each demonstration, give explanations of the more elementary parts of the subjects taken up in the demonstrations.

Demonstration No. 1 (Friday, February 4th. Repeated Wednesday, February 9th. 5 p.m.).—*Series Dynamo:* Practical modes of measuring the power given out by a series dynamo. Experimental determination of the increase of resistance, and the waste of power due to the self-induction of the armature. Measurements of the E.M.F. of the dynamo, when any current whatever may be passing through the armature, without knowing the current, resistance or self-induction of the armature. Experiments to test whether a series dynamo has a critical speed. Experimental determination of the true law of variation of E.M.F. with speed, either when the current is constant or when the resistance is constant. Experiments on the resistance in which the maximum useful work is done by a series dynamo running at a given speed.

Demonstration No. 2 (Friday, February 11th. Repeated Wednesday, Februaiy 16th. 5 p.m.).—*Shunt Dynamo:* Measurements of the useful power given out by a shunt dynamo. Experimental determination of the effect produced by varying the resistance of the shunt. Finding the true form of the curve connecting potential differences and current in the outside circuit, also the true form of the curve connecting the current and E.M.F. in the armature of a shunt dynamo. Experiments on the alteration of the general shape of the characteristic curve by altering the ratio of the ampere turns on the armature and field-magnet.

Demonstration No. 3 (Friday, February 18th. Repeated Friday, February 25th. 5 p.m.).—*Compound Wound Dynamo:* Combining a series and a shunt dynamo to obtain constant potential difference, or constant current. Compounding a dynamo. Experimental determination of the action of the shunt coil and of the series coil separately, and of the effect produced by the saturation of the iron cores of the field-magnet on the combined action of the shunt and series coils. Experiments on running a compound wound dynamo at different speeds.

Demonstration No. 4 (Wednesday, March 2nd. Repeated Friday, March 4th. 5 p.m.).—*Self-Induction and its Measurements:* Experiments on the effects of self-induction on an intermittent direct current with not very short period of intermittence. Alteration of effects when the period of intermittence is very short. Experiments on the effects of self-induction on an alternating current, and of the variation of the effects with the period of alternation. Unit of self-induction. Modes of measuring self-induction. Employment of commercial instruments for measuring self-induction, and the results obtained.

Demonstration No. 5 (Wednesday, March 9th. Repeated Friday, March 11th. 5 p.m.)—*Alternate Current Dynamo:* Useful power given out by an alternate current dynamo. Experimental determination of the speed correction to apply to a high resistance dynamometer used as a voltmeter, as well as the small speed correction of reading of a low resistance dynamometer used as an ammeter. Error in the common mode of measuring the power given out by an alternate current dynamo. Proper mode of measuring with an electrometer. Commercial form of electrometer for the purpose. Variation of the useful power with the external resistance and speed.

Demonstration No. 6 (Wednesday, March 16th. Repeated Friday, March 18th).—*Mechanical Measurement of Power:* Power given to a dynamo, measuring with a transmission dynamometer. Useful power given out by a motor, measuring with an absorption dynamometer. Determining the efficiency of a dynamo and of a motor, when running at different speeds and absorbing different amounts of power. Measuring the power wasted in a dynamo and motor by—1. Mechanical friction; 2. Magnetic friction; 3. Magnetic Lag; 4. Heat produced by currents; 5. Self-induction. Waste of power in its transmission from the engine to the dynamo, or from the electro-motor to the machine driven by it. Modes of diminishing this waste by the use of special methods of coupling the machines between which the power is transmitted.

Demonstration No. 7 (Wednesday, March 23rd. Repeated Friday, March 25th).—*Measuring Joint Efficiency of Coupled Dynamo and Motor:* By mechanically supplying the power wasted in the dynamo and motor combined, and measuring with a transmission dynamometer the power so supplied. By employing accumulators to furnish the total power wasted and measuring electrically the power furnished for this purpose.

The programme of the Institution and the calendar containing full particulars of the work of the Institnte may be obtained at Exhibition-road, S.W., or at the office of the Institution, Gre:ham College, E.C. The fee for the course is £1. 11s. 6d.

THE TELEGRAPHIC BREAKDOWN.

The snowstorm of Sunday, December 26th, will long be remembered as having proved more disastrous to the telegraph system of this country than any which has been hitherto experienced. On Monday morning (says *The Times*), out of nearly 500 wires connecting places outside the metropolis, only six were left standing. There was one to Belfast, one to Edinburgh, one to Glasgow, one to Liverpool, one to Manchester, one to Birmingham, and one to Dublin. Later in the day a second wire was got through to Liverpool, and a second to Birmingham, and by means of the latter communication was opened with Bristol. The work of repairing the damage was undertaken without delay, and on Wednesday the number of overhead wires in use was increased from nine to 29, additional lines being opened to Glasgow, Liverpool, Manchester (three being secured to each city),' Birmingham, Leeds, Cardiff, Derby, Southampton, Salisbury, Guildford, St. Albans, Uxbridge, and several other places of less importance. In the suburbs of London no fewer than

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250 wires were broken; but no interruption whatever occurred to the wires carried through underground pipes over what may be described as the commercial area of London. The boundaries of this district can hardly be defined in general terms, for the reason that the system of underground pipes has been developed by a series of spurs running in different directions. For instance, on one side of the City the pipes have been laid as far as Bromley, on another side they reach Barnet, while in a third they extend to Uxbridge. Many intermediate places have to depend for telegraphic communication solely upon overhead wires, and it is these which suffered under the pressure of snow and wind on Sunday night. The Stock Exchange has lost every single wire which it possessed, and most serious inconvenience was on Wednesday the result. The Submarine Telegraph Company is in an equally unfortunate position, and the services with France, Belgium, and Holland are entirely suspended. As far as the officials of the Post Office have at present been able to ascertain, the greater part of the destruction has occurred within a radius of 100 miles from London. At Maidenhead the wreck is complete, every pole and wire having been thrown to the ground, while the line from London to Lowestoft has also been dismantled. Wires carried along high roads and railways have suffered alike disastrously, and iron posts broke as often as those of wood. North of Birmingham and in Scotland and Ireland the wires were not affected by the storm, and local communication is going on as usual. All sorts of expedients have been adopted by the authorities of the Telegraph Department with the object of minimising the effects of this wholesale derangement. Thus the service between London and Cardiff has been resumed *viâ* Birmingham. Aid has been summoned from parts of the country where the violence of the storm was not experienced, and gangs of men were yesterday sent to assist those stationed in the southern and eastern districts. Application has also been made to the War Office, and it is expected that the staff engaged in the work of restoration will be augmented not only by an increased number of Royal Engineers, but by members of the railway, field telegraph, and other corps in the Army. It is the practice of the Telegraph Department to keep in each district the name and addresses of competent men who can be called upon in emergencies to repair the wires, and these, too, are being set to work wherever their services can be secured. In the meantime thousands of telegraphic messages have to be sent by train. On Monday—although it was Boxing Day—20,000 messages were received at the Central Telegraph Department, and by far the greater part of them had to be forwarded by rail, being made up into special parcels, and despatched by the ordinary trains. Over 6,000 messages passed between different parts of London, and owing to the immunity which the underground wires enjoyed in the general wreckage they were not in any way delayed. The overhead wires which have been damaged in London are as a rule those of one or other of the telephone companies, and not of the Post Office, the underground system having in recent years been extended to such a degree that every main line in the metropolis, as also in the large provincial towns, is now carried in pipes laid below the street pavement. Of the extent of the disorganisation the following communication, which was issued on Monday by the Secretary to the Post Office, will give some idea:—"Telegraphic communication totally interrupted from London to the east, south east, south, and south-west of England. Partial interruption to the north of England, Scotland, and Ireland, with heavy delay, but the communication in the north of England, Scotland, and Ireland is generally good. There is no delay to the inner London local traffic. The Submarine Company give notice of total interruption to the Continent."

In Walworth, Newington, Blackfriars, Southwark, Bermondsey, Rotherhithe, and other adjoining districts, there was scarcely a set of overhead wires intact. In all the principal thoroughfares of the neighbourhoods referred to, hundreds of wires were drooping across from one side of the road to the other, so low that police officers were told off to warn drivers of the danger. Besides the drooping wires some hundreds which actually fell to the ground were cut by the police and secured in a place of safety. In some cases, on the telegraph poles giving way, the roofs of houses were uplifted and numberless chimney-pots knocked over, some of them falling into the street. In the City the telegraph and telephone wires have suffered most severely. In the area stretching from the Mansion House to the Baltic the great network of wires and cables were either hanging low down under their weight or snapped asunder altogether.

All telegraphic communication from London and the provinces to the central and southern parts of Europe by the ordinary routes has been interrupted. Numerous messages from those countries have been received by the lines of the Great Northern Telegraph Company, who are prepared to receive outward messages at the higher rates as prescribed by the International Telegraph Convention if marked "*via* Northern."

The telegraph wires on the South-Eastern, London and Brighton, and London, Chatham, and Dover lines were pulled down in all directions. At the bridge crossing the roadway at St. John's (South-Eastern Railway) a telegraph post, fixed by iron clamps to the wall, was pulled by the weight of snow on the wires down on to the railway, bringing with it about 12ft. of solid masonry and brickwork.

At Dover the damage to the telegraph wires has been most extensive and disastrous, the town being entirely cut off from communication with any towns except one or two within a radius of six or seven miles. There are three sets of wires from Dover—those of the General Post Office, the South-Eastern Railway, and the London, Chatham, and Dover Railway. All of these suffered alike, the London and Chatham lost communication except as far as Faversham, and Deal and Folkestone were the eastern and western extremities of telegraphic communication yesterday morning, all telegrams received at the post office being sent by train to London and places at a distance.

The telegraphic service at Cambridge was blocked all round, and considerable damage was done by the breaking of the telephone wires. By 10 o'clock on Sunday evening communication between Birmingham and London had entirely ceased, all the wires being down along the canals, roads, and railways. Communication with all western and northern districts was also stopped, as well as with Scotland, Ireland, and the Continent. There was a total cessation of telegraphing from 10 o'clock until about 2 yesterday morning, when communication between Birmingham and London was successfully established *viâ* Manchester. At eight o'clock in the evening the telegraph service at Bristol was completely suspended, and after that hour there was no communication with the districts beyond the city, and all telegrams were refused by the officials. The line of the Great Western Railway between Reading and Oxford was blocked by fallen telegraph poles; but communication was soon restored and trains were run, though with a good deal of irregularity, owing to the damage done to the telegraph wires. In many places the telegraph poles were broken in two, and almost all along the line of the Great Western Railway between London and Reading the wires had either been snapped or the poles had fallen across the line. Large numbers of men were to be seen at intervals busily engaged in removing the obstructions to traffic, and where it was possible repairing the damage occasioned by the storm. Salisbury and other towns have been completely cut off, telegraph poles and wires in all directions having come to grief. The last train from Uxbridge for West Drayton Junction, on the Great Western Railway, soon after its arrival at the latter station, was delayed for the night by a network of wires, the engine driver and stoker narrowly escaping serious injury. The last up train on the main line was stopped at the same point, many of the telegraph poles between there and London having fallen with the wires across the railway and so caused a dead block. The telegraph poles had in many instances snapped off short, and more than a hundred were reported to be down between Paddington and Slough, exclusive of those on the branch lines, where the damage was also serious. Between Bristol and Bath as many as 50 poles were broken clean off by the force of the wind. A train from Bristol to Salisbury on Sunday evening came into collision with a telegraph post which was lying across the line, but fortunately only one passenger was hurt, and his injuries were not of a serious nature. The same train afterwards encountered so many fallen poles that it was deemed unsafe to proceed, and at Heytesbury the passengers were made comfortable for the night in the waiting-room. Further west the damage was very great, Yeovil, Taunton, Exeter, and most of the smaller towns in Devon and Somerset were entirely cut off from communication. At Plymouth, however, no snow fell, and not *a single wire was damaged.*

CONCERT BY THE STAFF OF THE EASTERN TELEGRAPH COMPANY.

For the last five years a concert has been given in the East End of London by the staff of the Eastern Telegraph Company, assisted by friends, for the purpose of raising funds to provide Christmas dinners for the poor in their own homes. This year the concert was given in the Great Assembly Hall, Mile End-road, E. (Mr. F. N. Charrington's), an edifice of palatial proportions, at which Sir JAMES ANDERSON took the chair. There were about 3,000 persons present.

In opening the proceedings the chairman said: My part of the programme this evening is a very simple one. My business is to act as a sort of figurehead, and introduce those ladies and gentlemen who have so kindly volunteered to help us. At the same time I have something to say before we commence the programme, but I will not occupy you more than three or four minutes. One cannot come here to a hall like this without a certain amount of reflection and going back over one's own lifetime and thinking what it all means. Ladies and gentlemen, I can go back so far as to be able to tell you that I rowed in a boat race on the Queen's coronation day—that is a long time to go back—and a few years after that I had in my vocation of life (that of a sailor) to be frequently in the Docks in this neighbourhood, and I can tell you that in those days there was no such great hall as this in all London for this kind of entertainment, neither East, West, North, nor South, and we had to go a long way from the Docks if we wanted to pass an evening of the kind. In those days a walk from the West End to St. Katherine's Docks took almost as long as it does now to communicate with Australia or California. Now, I could not help thinking, as I came into this hall a few minutes ago, how much you and I and all of us are indebted to the gentleman who had the heart to build it (applause) for the benefit of his fellow citizens. I certainly honour that gentleman, although I have never seen him, for the great good he has done—more, I think, than he is aware of (applause). Let me say a few words, and tell you what these reflections gave rise to in my mind. It is a long time to carry one's memory back to the coronation of our good Queen, and it is hardly possible to tell the story of the great and marvellous changes that have occurred since then. We have had steam, electric telegraphs, iron ships, instead of the wooden ships which one used to travel in in those days, and the result of all this is that those great factors—railways, steamships, and telegraphs—have, I believe, changed the whole future of the world. Since the days of which I speak the population of the United Kingdom has doubled, and if it had not been for these great changes I do not know what would have been the result. As it is, we have sent ten millions of our countrymen, old and young, to spread the English name and language all over the world. This could not have been so but for the improved communication by steam to our colonies all over the world; and yet the cry is that there are too many of us in these islands, more than could have been fed fifty years ago. But nowadays it is as easy to get to our colonies and to trade to all parts of the world as it was to trade when I was a boy between Liverpool, Glasgow, or Birmingham. I see before me to-night lots

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of young people, and I want to tell you this—and bear it in mind, for it will do you no harm—the changes that I have seen, great as they have been, are to my mind nothing to what you are going to see by-and-bye. You will be able to tell the young folks of the period, 25 or 35 years hence, of all the great changes that have taken place since the days of Queen Victoria's Jubilee. You will tell them of the introduction of free education, of greater social intercourse between all classes, of science matured, and such things as the electric light, just coming into general use, and you will have the advantage of knowing which of all the great factors I have referred to has made the greatest mark upon the past generation of your own life time: for at present we are too near, too mingled with the changes which science is making, to realise the relative value of one more than the other. But my conviction is that you young folks are on the threshold of a great social revolution of a very stupendous character. If you will watch it, and work and wait, and not be too anxious about the result, and not too eager to do anything special, but just to do the best you can, many of you may live to see great changes, and then I hope you will take care to act only as will add to the glory of this nation and its prosperity. It is not given to everyone, of course, to be great nor to be very conspicuous, but everyone in my opinion can help, and those who work bravely and patiently in the vocation in which they are called can do something to help to make the history of this land. No nation can be great which has not a vast crowd of makers of unwritten history, and upon the youth of this nation rests the duty of keeping the history of this country as bright in the future as it has been in the past (applause). And now, ladies and gentlemen, let me say what great pleasure it gives me to be present to-night in aid of this fund to provide Christmas dinners for those who are not so fortunate as we are. There are always some who are struggling, as it were, against a strong tide and hardly managing to keep afloat, and there will always be a great number who only make leeway. I am here to-night with a number of young men who are pulling in the same boat as myself in our daily work with the hope that we shall do some little good; but I may not detain you longer, the programme is long one, and I will only ask you to join with me in giving hearty thanks to those who have kindly come forward to assist (applause).

The speech, which was listened to throughout with the greatest attention, was then followed by a capital concert, all the *artistes* being well received. Amongst the vocalists were Mr. W. J. Finnis, Mr. J. F. Harrap, and Mr. Leyten Barker. Miss Maude Snell sang in perfect style "Esmeralda," for which she was rapturously encored. Mr. A. R. H. Mackay gave "The Lost Chord" on the cornet, and was very well received. The performances of the Apollo Orchestral Band were very warmly applauded. The palm of the evening, however, was certainly carried off by Mr W. A. Owen, who, in reciting "Asleep at the Switch" and "A Street Arab's Story," created great enthusiasm. Mr. Arthur Briscoe presided with great ability at the piano and organ.

This entertainment was by far the most successful yet given in connection with this charity, which was attributable in a very large degree to the genial presidency of Sir James Anderson. By means of this concert and other contributions about 200 families, representing about 800 persons, were supplied with the requisites of a good substantial Christmas dinner on Christmas Eve, under the superintendence of the chairman of the dinner fund, Mr. E. H. Kerwin.

Too much praise cannot be given to the staff of the Eastern Company for supporting so heartily this good work for the East End poor. The concert and dinners are organised by Mr. Thos. Richardson.

COMPANIES' MEETINGS.

New Telephone Company (Limited).

The second ordinary general meeting of the shareholders of this Company was held at the offices of the Company, 4, Great Winchester-street, E.C., on Saturday, 18th inst., Lord Thurlow (the Chairman) presiding.

The CHAIRMAN, in moving the adoption of the report, stated that the Company had been successful at the commencement of its business in obtaining the license of the Postmaster-General. The telephone which the Company supplied to the public was the invention of Dr. Silvanus P. Thompson. At first some little disappointment was experienced when it was found that the instrument did not prove so efficient for exchange work as had been anticipated. Since then improvements had been introduced into the instrument, which rendered it thoroughly satisfactory, and he (the Chairman) firmly believed that the Company now possessed an instrument which was distinct and clear in its articulation, was a most valuable instrument for long distances, and was, in fact, second to none in the world. Although the Company had only quite recently commenced selling telephones to the public, it was encouraging to be able to record that their sales were steadily increasing. Their telephones were now being freely sold in all the principal English and Scotch towns and provincial districts, also in Ireland and in Wales, and testimonials proving their efficiency were daily coming in from customers. With regard to the financial position of the Company the Chairman was happy to say that it was eminently sound. In reference to the future policy of the Company, it was intended at the beginning of the new year to form a large and powerful company, and, inasmuch as the Company's patents were now known to be very valuable property, he felt convinced that there would be no difficulty in the formation of such a company. Moreover, the circumstances of the Company's business rendered it necessary that a large company which would be competent to further develop the business now established should be formed without delay. In order to be successful on a large scale, the Company must open exchanges, and these could not be efficiently organised except by a powerful company. Numerous applications from towns and cities in the United Kingdom had been received by the Company with reference to the establishment of exchanges, and it would be the object of the new company to deal with these applications. In one of the most important installations undertaken by the Company, there was some difficulty in overcoming the induction caused by the immediate proximity of an electric railway, but the installation was at last successfully and satisfactorily accomplished. On the line referred to, another telephone, in extensive use in this country, was tried, but the induction was very much more perceptible than with the Company's instruments. Their telephones were working perfectly in noisy factories in the north of England, where the circumstances were far from favourable for the good working of a telephone.

Dr. THOMPSON then addressed the meeting, and explained the improvements which had been made in the instrument. These improvements, he said, were nearly all of them mechanical details, in developing which Mr. John S. Sellon had kindly rendered the most valuable assistance.

The adoption of the report was seconded by Sir JAMES M'GAREL-HOGG, and unanimously agreed to, after which the retiring Directors—Sir Daniel Cooper, Bart., and Mr. J. Irving Courtenay were re-elected. The re-election of the auditors—Messrs. Deloitte, Dever, Griffiths, and Co., having been also agreed to, a vote of thanks to the Chairman and Directors of the Company concluded the business of the meeting.

Simplex Electrical Syndicate (Limited).

The first ordinary general meeting of the shareholders of this Syndicate was held on the 29th inst. at the offices, 109, Farringdon-road, London, under the presidency of Mr. C. L. W. FitzGerald.

The SECRETARY (Mr. W. J. Milne Menzies) read the notice convening the meeting, and the minutes of the statutory meeting were taken as read, and signed by the Chairman. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, this Syndicate, as you are aware, was formed for the purchase and working of certain patents, the principal being for an arc lamp and for an electric printing machine or tape record. When we bought these patents we of course thought, as a good many others would have thought, that we should find a very ready sale of our arc lamp for two reasons, one being that it was an extremely steady light, and the other on account of its, I may say, extraordinary cheapness. On going a little further into the matter we discovered that nearly everyone who was a large manufacturer had a patent of his own for an arc lamp, and the result was that, instead of, as we expected, selling those arc lamps to any great extent, we found it would be absolutely necessary for us to go into installations. I need not remark that the capital of this Company was by no means adequate for that, and therefore the Board had to consider what was best to be done. We have come to the conclusion that the best thing we possibly could do is to use our utmost endeavours to sell the patents we have taken out for the arc lamp. We have taken out patents of this lamp in the United Kingdom, Austria, Belgium, France, Germany, New South Wales, New Zealand, South Australia, and Victoria. We have come to the conclusion, as I have said, that it will be the best thing for us to try and sell these patents, either for a lump sum, or else under a system of royalties, and we are using our utmost endeavours to effect the sales of these patents. I should tell you that we have had trials at various places. Perhaps the most satisfactory trial that we have had has been at the General Post Office, St Martin's-le-Grand, and through that we have received an order for six small arc lamps on trial. We are at this moment testing lamps to send to the Edison Company of Germany in Berlin, and I hope that when they have received these lamps and tried them they may feel disposed to purchase the patent for Germany. In addition to that we have had trials at Vienna and Paris, and both, I think, have been satisfactory, though as none of our people were there we cannot say exactly what happened These trials were made by the Imperial Continental Gas Association. I should further tell you that we had a trial at the works of the Gülcher Electric Light and Power Company, and the Chairman, the managing director, and a number of people who were present at that trial expressed themselves very much satisfied with the lamp. Moreover, that company made a proposal, on certain terms, for the purchase of the lamp, but your Directors did not consider it was good enough, and, therefore, the matter dropped for the time being. The next point that I consider of great importance is that we have got permission to instal five arc lamps at the Liverpool-street station of the Great Eastern Railway. This, I believe, will probably result in our being able to sell some lamps to that company, and through them no doubt we shall eventually sell lamps to other railway companies. Almost by accident, as I may say, we had the offer made to us to finish the lighting of the hospitals, on the ships and on shore belonging to the Metropolitan Asylums Board at Dartford. As this work, of course, did not require a very large capital we were only too happy to do it, and we finished the work successfully, and have been paid for it. There is no doubt that our lamp is one that can be made very cheaply, and as far as your Board are concerned they undoubtedly think the lamp is one of the steadiest, if not the steadiest arc lamp in existence. It comes to this, therefore, that probably some one or two companies may purchase this patent, and if it is purchased at a royalty it will of course be a very good thing for the shareholders. We have done, as you can see on examining the accounts, all we can to keep down the expenses. The large item, of course, is wages. That certainly is a very large sum in proportion to the other items, but we cannot possibly do without workmen, so we can say no more on that head. As far as our stock and plant are concerned, I think we have taken them at a low valuation. We have still a considerable sum in hand—

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£1,462. I may add that last week we placed in the hands of the Anglo-American Brush Corporation one of our arc lamps to test, and but for the telephone wires having broken down, I should have inquired to-day before this meeting as to whether they had done anything with that lamp. I will now propose:—"That the report, balance-sheet, and accounts received from the Directors be adopted." But before I put the resolution I shall be very happy to answer questions if gentlemen have any to put.

Major H. T. G. FitzGerald inquired at what price the "simplex" lamp could be made.

The Chairman: We consider that the lamp can be made for 30s. to 35s. without the globe. The cost of other lamps varies from £5 to about £12. I presume that is also without the globe, but I am not quite certain.

Mr. Richard Van Zeller then seconded the resolution, which was carried.

The Chairman said that they had to consider the question as to the time of holding their future meetings. The present report was for a term of ten months up to the 30th ult. He thought that a good time for the termination of their financial year would be the 31st October. They had had rather a "scramble" in getting the present report out, as the time was very awkward owing to the Christmas holidays. He thought it would be well in future to let their financial year end on the 31st October and to hold the annual meeting in November or early in December. So far as the current year was concerned, that would give them eleven months' working. He did not think it was necessary to submit a resolution on the point, but if what he had said met with their approval he would enter it on the minutes. In reply to a shareholder, he said that if they were to decide on an earlier period for the meeting—say, in September or August—everyone would be away for his holidays.

Mr. Thornton said that October would be a very busy month for the Company in connection with the question of manufacturing, and he therefore thought there would be some difficulty as regarded the stocktaking.

The Chairman said he believed there would be no difficulty, and if they were busy he might have the satisfaction of telling the shareholders something that would be pleasant for them to hear.

The suggestion having been approved,

Mr. Van Zeller proposed, and Mr. R. E. Bateman seconded, the re-election of Mr. FitzGerald to his seat at the Board.

On the motion of Major FitzGerald, seconded by Mr. G. A. Mason, Mr. R. E. Bateman was also re-elected a Director.

Mr. Arthur E. Green having been re-elected auditor,

Mr. Mason proposed, and Mr. Thornton seconded, a vote of thanks to the Chairman, which was carried unanimously.

The Chairman, in acknowledging the vote, assured the shareholders that the Directors would do all they could to promote the welfare of the Company.

The shareholders were afterwards invited to inspect the lamps and tape record.

The Pilsen, Joel, and General Electric Light Company (Limited and Reduced).

The fifth ordinary general meeting of the shareholders of this Company was held at the Cannon-street Hotel, on the 23rd inst., under the presidency of Sir Rawson W. Rawson, K.C.M.G., C.B.

The Secretary (Mr. W. H. Trentham) read the notice convening the meeting, and the report of the Directors was taken as read. It stated that the resolution recently passed for a further reduction of the Company's capital had been duly confirmed by the order of the Court. The accounts and balance-sheet embraced the period from 30th June, 1885, to 30th June, 1886, and the capital therefore appeared as it stood on the latter date. The amount of calls in arrear was reduced during the year by nearly £500, and the Board had since felt it their duty to forfeit the shares of those still in default. The number so dealt with was 3,517 shares, leaving 24,483 partly paid up shares outstanding. The paid up capital of the Company therefore at present stood at £30,828. 15s., of which £30,603. 15s. was represented by £1. 5s. per share now credited on the 24,483 outstanding partly paid up shares, and £225 by the 100 fully paid up shares now reduced to £2. 5s. each. They congratulated the shareholders that during the period dealt with in the accounts (the first year's working at the new factory) a net profit of £1,111 was realised. The Board had, subject to the sanction of the general meeting, declared a dividend on the present paid up capital of the Company, at the rate of 8d. per share on the partly paid up shares, the equivalent amount in respect of the fully paid up shares being 14d. per share. This payment would absorb £822, leaving a balance of £289 to be carried forward. Mr. Trentham continued his manifold duties to the complete satisfaction of the Board. The revenue account showed that the receipts, by sundry sales, had been £3,203, and by rents, &c., from installations, £3,291, while under the head of "sundry receipts" (principally royalties—£368) a revenue of £548 had been obtained.

The Chairman: I will now move the first resolution, which is the adoption of the report, with the accounts and balance-sheet for the year ended June 30, 1886. I need not detain you long in submitting that proposal. When we met on the last occasion, in the middle of 1885, we undertook, at a time of difficulty, to carry on the affairs of the Company in such a manner that we should not, at all events, lose any of the remaining capital, and that we should keep the affairs of the Company in such a condition that whenever electric lighting was likely to come into general use, by some Act of Parliament, which would lead to street lighting, and consequently the development of the lighting by arc lamps, which is our principal patent, we might take advantage of the improved times. With regard to the difficulties which have attended the question of incandescent lamps, as soon as the contest between the Swan and Edison Company and the firm of Woodhouse and Rawson on the subject of the rights of the former Company is settled, we have reason to hope that the electric light will take a decided development. We have, therefore, not wasted our small funds in making attempts at development which had not succeeded up to last year, and which we had no reason to hope would result more favourably; but we have kept down our expenses to the lowest ebb. We have availed ourselves of every occasion of making a profit, and almost unexpectedly to ourselves we are able to submit a balance-sheet showing an actual profit during the past year ended June, 1886, which will enable us to offer a dividend to our shareholders. I may also add that affairs have gone on quite as favourably since, and that the prospects of the remaining half year are equally favourable. We, therefore, have reason to expect that this is the commencement of a resuscitation of the interest of the Company, though the capital which was embarked in it at first has been absorbed—lost, in fact—for unless something exceptional occurs we cannot, of course, look forward to replacing that capital. Upon the reduced capital, however, for which we have obtained our order, and which now stands at £25,000, we hope to maintain a fair profit, which will enable us to offer a reasonable dividend, and perhaps in the future even more than a reasonable dividend—a large dividend—on that reduced capital. I therefore have great confidence in asking you to accept and adopt this report and balance-sheet.

Mr. Thomas Weyman (a shareholder) seconded the motion, which was carried unanimously.

The Chairman next proposed the declaration of the dividend of 8d. and 14d. a share, as mentioned in the report of the Directors. The shareholders, he said, would see that the Directors, acting like men of business, had not attempted to divide the whole amount of profit and increase the dividend by 1d. or 2d. a share. They had proposed for division what they considered money actually and fairly earned, leaving something towards next year, with the view of being able to divide at least an equal amount then.

Mr. James Fyfe (a shareholder) seconded the motion.

A Shareholder: Is the amount of £3,500 still invested in consols?

The Chairman: £4,500. He then put the motion, and it was carried unanimously. Continuing, he proposed the re-election as a Director of Mr. Horace W. Scriven.

Mr. Wm. Mogg (a shareholder) seconded the resolution, which was carried unanimously.

On the motion of Mr. Fyfe, Messrs. Broom, Hays, and Akers were re-elected auditors to the Company.

The Chairman, in announcing the conclusion of the business of the meeting, assured the shareholders that the Directors had the interests of the Company at heart, and that they would do their best to secure a good dividend and the prosperity of the Company.

On the motion of Mr. Akers a vote of thanks was passed to the Chairman and Directors, and the proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Dec. 29.		Business Done Week Ending Dec. 29. Highest.	Lowest.
Anglo-American	35½,	36½	—	—
Do. Preferred	59,	60	59¾	59
Do. Deferred	13,	14	13¾	13⅝
Brazilian Submarine	10⅞,	11⅛	11⅛	10⅞
Cuba	10¾,	11¼	—	—
Do. Preference	18,	19	18⅜	—
Direct Spanish	1¾,	2¼	—	—
Do. Preference	9½,	10½	—	—
Direct United States Cable	8¾,	9¼	9	—
Eastern Telegraph	10,	10¼	10¼	10 3-16
Do. 6 per Cent. Preference	13½,	14	13¾	—
Do. 5 per Cent. Debentures, 1899	106,	109	106½	—
Eastern Extension	10⅜,	10¾	10⅜	10⅝
German Union	9,	9½	—	—
Globe Telegraph and Trust	5¼,	5⅜	5 5-16	5
Do. Preference	12¼,	12⅝	—	—
Great Northern	13⅜,	13⅝	13⅝	—
Indo-European	34,	35	—	—
Reuter's	7,	7½	—	—
Submarine	190,	200	—	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	8½,	9	8⅞	—
Western Brazilian	7⅛,	7⅜	7⅜	7 3-16
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	⅜	—	—
Oriental	3-16	5-16	—	—
United Telephone	12¾,	13¼	13 9-16	12⅞

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	2⅞	—
Do. (fully paid)	4½,	4¾	—	—
Swan	1½,	2	—	—
Maxim Weston	5-16,	7-16	—	—

MISCELLANEOUS.

Telegraph Construction	39	40	—	—
India Rubber, Gutta Percha, and Telegraph Works	24	25	24½	—

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NOTES.

BRO. M——S.—Hearty good wishes. No. 1,768.

TO OUR READERS.—A happy, busy, and prosperous year.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 31st amounted to £3,538.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending 31st December were £4,590.

THE BALLOON SOCIETY.—A lecture on "The Electric Telegraph Jubilee" is announced to be delivered at the Royal Aquarium by Mr. Thomas Moy, C.E., on Friday evening next at eight o'clock.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending December 31st were £2,869, after deducting the fifth of the gross receipts payable to The London Platino-Brazilian Telegraph Company.

ELECTRIC LIGHT IN THE NAVY.—The Admiralty has recently issued a circular, requiring that all ships provided with electric search lights shall exercise their crews twice each year at target firing and defence against torpedo boats under the search light.

THE GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of the above company are as follows:—Receipts for December, 1886, £19,600; 1st January to 31st December, 1886, £258,600; corresponding months, 1885, £284,720; corresponding months, 1884, £276,280.

ELECTRIC LIGHTING OF MILAN CATHEDRAL.—It is stated that the Pope has at length overcome his long-entertained scruples about admitting so heretical a power as electricity into the sacred precincts of Milan Cathedral, and has consented to its being lighted electrically.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of December was 3,695, estimated to produce £3,100, against 3,023 messages, producing £2,448 in the corresponding month of last year. The traffic receipts for the month of September, estimated at £2,250, realised £2,272.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company have declared an interim dividend for the quarter ended 30th September last of 2s. 6d. per share, free of income-tax, payable 15th January.—The traffic receipts of this company for the month of December amounted to £40,539, and to £34,785 in the corresponding period of 1885.

THE POSTAL TELEGRAPH REVENUE.—The Revenue Returns for the nine months ended December 31, 1886, show a decided improvement in the receipts derived from the telegraph service. The increase on the corresponding period in 1885 is £40,000, the major portion of which has been earned in the last quarter of the year just ended. For the whole year the increase is £30,000, the figures being £1,780,000, against £1,750,000 for 1885.

SALE OF PLANT AT SOUTH KENSINGTON.—We would call the attention of our readers to the announcement which appears in our advertisement columns of the forthcoming sale, by Messrs. Wheatley Kirk, Price and Goulty, of the engines, boilers, dynamo machines, arc and incandescent lamps, and general electrical plant and instruments, which were used for the electric lighting of the Indian and Colonial Exhibition.

THE BURMESE TELEGRAPHS.—The *Indian Engineer* says that the telegraph line connecting Bangkok with Burmah has been working satisfactorily in spite of the difficult country through which it had to be taken. It will shortly be duplicated by another, crossing the hills between Siam and Burmah at Myawadi, to the north of the present line. Another line is in course of construction, passing from the capital down the east side of the coast of the gulf.

LINDAL-IN-FURNESS.—The *Whitehaven News* mentions that Messrs. Harrison, Ainslie and Co., of Lindal Moore Mines, have extended their system of electric lighting to their Lindal Cote Works, and in doing so have placed three lamps in prominent situations in the village. A storage chamber has been constructed in the new church, and a number of lamps have been put up, and it is expected that the church will shortly be lighted with electricity.

THE PRICE OF CARBONS IN AMERICA.—There are nine large companies engaged in the manufacture of carbons in the United States. Seven of these have recently entered into a mutual agreement respecting the price of their wares, and have issued a joint circular to their customers. The prices agreed upon are quoted per 1,000ft. as follows:—$\frac{7}{16}$in. by 12in. at $12, $\frac{1}{2}$in. by 12in. at $15, and $\frac{5}{8}$in. by 12in. at $25, shorter lengths and odd sizes in proportion, plus a stated percentage.

A FRENCH INSTALLATION.—The Eldorado Theatre and Café has recently been supplied with an installation of 35 arc lamps. To provide current for this number of lamps it has been thought desirable to employ *seven* A Gramme machines, each capable of supplying five lamps only, so that with all these dynamos there are none to spare in case of a breakdown. Electric lighting is scarcely one of those things which they have learnt to do better in France up to the present time.

A NEW SOURCE OF CARBON.—It is stated that an excellent carbon for electrical purposes can be obtained from sea-weeds. After thorough washing in hot water the material is dried and is then carbonised in closed retorts in the usual manner. The resulting product is then treated with dilute acid and dried. It is then said to be a perfectly pure form of carbon in soft masses or lumps, which may easily be crushed between the fingers, and after being ground makes an excellent raw material for the various purposes for which carbon is applied.

NEW RAILWAY ALARM.—The engineers of the French Western Railway are trying a new arrangement for communication between passengers and guard. It consists of pushes in the carriage compartments, wires along both sides of the carriages, and a bell and dial in the guard's van. The dial enables the guard to see from what compartment a signal proceeds, while switching off the wires on the near side of the carriages, on the train approaching a station, permits of his also being warned of any passenger attempting to alight or change compartments on the off-side.

DOCKYARD LIGHTING.—The *Broad Arrow* says:—"Times have advanced so fast that our Admiralty scarcely are able to keep pace with them. It is, however, to be hoped they will shortly turn their attention to the lighting our dockyards by electricity, and so increase their efficiency, which can be easily done at a small cost. The necessary steam-power is always available. The great advantage that would naturally accrue at night when, as is often the case, it may be necessary to work over hours, would be simply invaluable." We have reason to believe that this matter is now receiving attention at the Admiralty.

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THE EASTERN TELEGRAPH COMPANY.—This company announce the payment, on the 14th instant, of interest at the rate of 3s. per share on the preference shares, less income-tax, for the quarter ending 31st December, 1886, and on the same day an interim dividend will be paid of 2s. 6d. per share in respect of profits for the quarter ended 30th September, 1886, on the ordinary shares of the company, free of income-tax. The register of transfers will be closed from the 7th to the 14th inst., both days inclusive.—The traffic receipts for December, 1886, amounted to £52,823, and to £53,179 in the corresponding period of 1885.

MILL LIGHTING.—We are glad to note the steady extension of electric lighting among the mill owners in the Leeds district. One of the latest installations of this character has been carried out by Mr. Wilson Hartnell in Messrs. W. and J. Bairstow's mills at Skipton, in extension of plant supplied four years ago. The new plant consists of one of Hartnell's compound-wound dynamos, supplying fifty-eight 16 candle-power Edison-Swan lamps, with movable fittings for examining the machines. The dynamo is driven by a 4 horse-power nominal vertical engine, fitted with Hartnell's automatic governors, the power being transmitted by belting.

AVELLINO, ITALY.—We learn from *Industries* that a contract for the electric lighting of Avellino has just been concluded between the municipality of that town and Messrs. Taddei, electrical engineers, of Turin. The installation will consist of 250 incandescent Cruto lamps, viz, forty of 32 candle-power, thirty of 24 candle-power, eighty of 16 candle-power, and 100 of 10 candle-power each. The Piazza della Libertà will be lighted by arc lamps of 250 candle-power. The current will be furnished by Thury dynamos, driven by a compound condensing engine of 150 horse-power. This engine and the two boilers will be supplied by Messrs. Tosi, of Legnano.

THE COWLES PROCESS.—The *Engineering* and *Mining Journal* of New York says that the success of the Cowles electric smelting process for the reduction of aluminium appears to have passed far beyond the experimental stage since the starting of the great dynamo. The working of this machine has proved so satisfactory that two additional dynamos of the same force have been contracted for, the present capacity of the works being unequal to the demand for their product. The use of aluminium alloys for guns is attracting a good deal of attention, and every process that tends to the cheaper production of aluminium is of the greatest interest and importance.

THE "ACHESON" DUPLEX WIRE.—Preparations are being made in the Pittsburgh factories of Mr. G. Westinghouse, jun., for the manufacture of a new type of insulated cable, intended primarily for telephonic purposes. The cable consists of a central wire, separately insulated, and surrounded by a copper tube ·006in. in thickness, made of electro-deposited metal, and insulated over all with cotton, treated with japanned paint. It is stated that this cable will not cost more than a cable of two separately insulated wires of the usual type. If this last statement is well founded, there can be no doubt that the "Acheson" cable will find a very extensive employment for underground telephonic work.

ATMOSPHERIC ELECTRICITY.—At a recent meeting of the Berlin Electro-Technical Society, Major Buchholtz, after describing some experiments which he has undertaken for the examination of the electrical condition of the atmosphere by means of a captive balloon, referred to a new observation of Dr. Vettin, by which he proposes to account for the fleecy rounded shapes assumed by cirrus clouds. According to the Doctor, if a mouthful of cigar smoke be gently blown along the surface of a table, and a charged electrophorus be brought near, the smoke will assume just this aspect. It is therefore suggested that the presence of such clouds denotes a highly electrical condition in the upper regions of the atmosphere.

DIRECT SPANISH TELEGRAPH COMPANY.—The reduction of capital having been sanctioned by the High Court of Justice, in the terms of the resolutions passed at the meetings of the 30th September and 19th October last, it will take effect from the present date (December 31st), and shareholders are requested to forward their certificates of shares to the manager, in exchange for which new certificates of the same shares as reduced will be issued. Holders of preference shares will receive with their new certificates a cheque for £2. 10s. per share, less income-tax, making up the full dividend payable upon their holdings in preference shares to December 31st, 1886.—The estimated traffic receipts of this company for the month of December were £1,767, against £1,764 in the corresponding period of last year.

ARC OR INCANDESCENT, IN 1834?—Arago, in his "Elogy of Alexander Volta," of which a translation appears in the *Edinburgh Philosophical Journal*, January, 1834, has the following passage:—"Pieces of charcoal fitted to the two extremities of the same wire, kindle as soon as they touch each other. The light they diffuse is so pure, sparkling, and remarkable for its whiteness, that we should not surpass the limits of truth by calling it the solar light. The charcoal attached to the two wires of the pile become, in fact, incandescent in a perfect vacuum. Nothing therefore can be incorporated in their substance, and nothing appears to emanate from them. At the close of an experiment, however long continued, the pieces of charcoal are found to be the same in nature *and in weight* as before it began."

ANOTHER ELECTRIC LOW WATER ALARM.—An automatic electric low water alarm for steam boilers of a particularly ingenious character has recently been introduced in America. The ordinary glass level tube contains a cork floating upon its surface, and this is all the apparatus which is placed in connection with the boiler itself. At the level at which the alarm is to be sounded a lamp is placed upon one side of the tube, and upon the other side a selenium cell is placed in circuit with a battery and an electric bell. The rays from the lamp are concentrated by a lens, but when the water is at its proper level the light is intercepted by means of the cork float. The resistance of the selenium cell is then so high that the current is unable to ring the bell. If, however, the water level sinks so as to allow the light to fall upon the selenium, the resistance decreases and the alarm is sounded.

LECTURES ON THE STEAM ENGINE INDICATOR.—The "special" lectures at the Finsbury Technical College for the present term will be delivered by Prof. Perry, F.R.S., who takes as his subject the "Steam Engine Indicator Diagram." We understand that Prof. Perry has had a number of pieces of new apparatus specially prepared to illustrate these lectures. The subject, though in one sense a purely mechanical one, is of great interest to electrical engineers, inasmuch as the correct measurement of the power supplied to a dynamo is frequently a matter of some moment. A course of laboratory instruction has been arranged in connection with Prof. Perry's lectures, thus carrying out the principle which pervades the Finsbury courses of instruction. Prof. Perry also proposes to continue the voluntary class for instruction in the simpler applications of the differential and integral calculus. It is not generally known that this class is open, free of additional charge, to all evening students of the classes at Finsbury.

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Telegraphic Communication with the Continent.—With regard to the statement that the recent breakdown of the British lines communicating with the Continent was due to the monopoly of a private company, Mr. Clare, secretary of the Submarine Telegraph Company—the company referred to—points out in a letter to *The Times* that several of the cables connecting this country with the Continent are the property, not of English, but of Continental companies; and that the English Government is itself the owner of two cables to Holland, and one to Germany. Mr. Clare adds that "The land lines which have broken down from London to the Coast in connection with all the cables laid down across the Channel to the Continent belong exclusively to Her Majesty's Government, who is solely responsible for their proper maintenance, and who alone can erect land lines in this country. None of the companies have the power to erect land lines in connection with their cables."

The French Academy Prizes.—The subject proposed by the Academy last year in competition for the "Grand Prize de Science Mathematiques," which consists of a gold medal of the value of 3,000fr., was the following:—To perfect in some important point the theory of the application of electricity to the transmission of energy. The committee of adjudication consisted of MM. Levy, Becquerel, Bertrand, Fizeau, and Cornu. They have reported as follows:—Only one memoir has been sent in upon the subject; this memoir, in spite of several points of interest, and a judicious discussion of the problem, has not seemed to the committee to sufficiently respond to the programme proposed by the Academy. Some experiments now in course of execution would seem to put the author in a position to obtain a more complete confirmation of his ideas. The problem of the electric transmission of power is now being made the subjeet of profound study from many sides. Under these circumstances the committee have thought it best to reserve their award for the present, and, without prejudice to the author of the paper already received, to allow the competition to stand open until June 1st, 1887.

On the Specific Induction of Magnets in Magnetic Fields of Different Intensity.—In the *Centralblatt für Elecktrotechnik*, Dr. Hilmar Sack has a paper to the following effect:—The specific induction of a magnet is the increase or decrease of the magnetic moment of the unit of mass by the unit of magnetising or demagnetising force respectively. Dr. Sack's experiments were conducted on a hardened steel bar, which had been strongly magnetised and subsequently treated for a long time in boiling water or steam, by placing it in a solenoidal coil, through which could be passed a current of given intensity either positive or negative in sign. The results are that, for magnetic fields of an intensity not exceeding six times that of the earth's horizontal component, the value for increasing and decreasing force is the same; this also holds good for fields up to seventeen times the earth's horizontal component, if the bar be first subjected to a series of reversals of the current, for the first application of the current gives a larger value than subsequent ones. No permanent alteration in the moment of the bar can be positively detected until the magnetic field is twenty times as strong as the earth's horizontal component.—*Journal* Inst. Civ. Eng.

Method of Indicating the Potential of Incandescent Circuits.—In central station lighting when worked direct from parallel distribution, whether with two or three wires, it is essential to have some means of knowing the difference of potential in various distant parts of the circuit. For this purpose it is customary to carry "pressure wires" from the terminals of the various feeders back to the machine room, and hitherto these wires have been connected with a voltmeter, which indicates, or should indicate, the actual differenco of potential in volts. As a matter of fact, however, unless much trouble is undertaken in the frequent and careful calibration of the instruments, it is found in practice that the error often attains a magnitude leading to serious differences in the potential actually maintained at various points in the circuit. In order to overcome this difficulty, and at the same time to avoid the necessity for re-calibration, Mr. John Howell, of the Edison Company of New York, has introduced a system by means of which only one standard instrument has to be calibrated in volts. This standard instrument is connected with the terminals of any one feeder; the "pressure wires" from all other feeders are connected with simple differential galvanometers, and the second circuit in each of these galvanometers is connected in parallel with the standard instrument. The needles then show at a glance whether the difference of potential at the terminals of each feeder is greater or less than that at the terminals of the standard. The idea is both simple and ingenious, and will undoubtedly receive a wide application.

Electrical Conductivity of Solid Substances at a High Pressure—In the *Ann. Phys. Chem.* a paper "On the Electrical Conductivity of Solid Substances at High Pressures" is contributed by L. Graetz. Hitherto our knowledge of the conductivity of electrolytes is derived for the most part from results obtained with the substances in the dissolved and not in the fused condition. Although it is *à priori* to be expected that the law governing these phenomena in the case of a homogeneous media would be of a simpler character than those in the case of heterogeneous media, namely, a solution of salt in water, yet the result of experience is the reverse. The only generalisation at present deduced is that solid substances are not conductors at low temperatures, but their conductivity commences at temperatures far below the melting point, and increases with the temperature. If, then, this increase of conductivity is due to an increase of molecular mobility and of the number of molecular impacts, increase of pressure without alteration of temperature should be effective to a like degree. In the paper this point is examined by means of a compression apparatus, capable of giving a pressure of upwards of 4,000 atmospheres. The results are given for the halogen compounds of lead and silver, and for sodium nitrate. The substances examined are divisible into two classes, in the one of which, with application of maximum pressure, the resistance rapidly decreases to a constant point, and in the other this minimum resistance is, under the same condition, only attained after several hours. To the former class belong the halogen compounds of silver, to the latter those of lead and sodium nitrate. In the paper full details are given of the apparatus used, and of the methods of experiments; the results are tabulated.—*Journal* of the Chemical Society.

M. de Meritens' Process for Rendering Iron Inoxydisable.—M. de Meritens, in continuing his experiments upon the protection of iron, has obtained some further results, which seem likely to be of practical importance. The method of protecting an iron or steel surface by the electrolytic formation of a coating of the black magnetic oxide has already been taken up in France as a commercial process. Experiments in this direction have also been undertaken in the French arsenals, and are understood to have led to satisfactory results. The details of the process, which is very simple and inexpensive, will be found in *The Electrician* of 23rd July, 1886. M. de Meritens describes his later researches in a note presented to the French Academy, as follows:—"When we

submit a piece of iron to the action of the current in a bath of cold water the formation of magnetic oxide does not immediately take place. The surface of the metal is in the first place coated with a layer of the protoxide of iron. This is a body of which little is known at present; it has not been completely studied by any chemist. Berzelius undertook a prolonged investigation of the substance, but he has never completed the work. The protoxide is the least stable of the oxides of iron. If it is produced by precipitation from a salt of iron, it is immediately converted into the sesqui-oxide. A similar conversion into the higher oxide takes place when the protoxide formed upon the surface of the metal by electrolysis is exposed to the air, or if the electrode is allowed to remain in the bath after the cessation of the current. If, however, the sheet of iron coated with the protoxide is immediately transferred to a bath containing a solution of a suitable salt of some other metal, such as copper, silver, gold, or aluminum, a perfectly adherent layer of this metal is immediately formed upon the iron. It is probable that the action is due to a partial reduction of the protoxide by hydrogen, and the formation of an actual alloy between the two metals, both of which are at the moment in the nascent condition." M. de Meritens exhibited specimens of iron coated by this process with the several metals named above.

Open and Closed and Magnetic Circuits.—Professor Mascart has recently undertaken some experiments in order to compare the coefficient of magnetisation in closed rings with that for cylinders of different lengths. Hitherto the coefficient in the former case has always been found to be higher than in the latter. The question arises (according to Prof. Mascart) whether one of the methods is liable to error; whether in rings, for instance, a special phenomenon exaggerates the effects of induction. In order to determine this question a series of electro-magnets were prepared, all of the same iron wire; some of these were closed rings, and others in the form of cylindrical rods in which the ratio of the length to the diameter varied between very wide limits. It was found that for the particular quality of iron employed, when the ratio of the length to the diameter varied from 40 to 500 or 600, the maximum value of the co-efficients varied from 25 to 190 or 40 to 220, while the corresponding magnetic fields diminished from 20 to 25 C.-G.-S. units to 3; the same wires employed in the form of rings gave similar values. Interpreting this result in the light of the views of magnetic resistance which now find acceptance upon this side the Channel, it is easy to understand (what, however, was well known long before Prof. Mascart's late experiments) that the coefficient of magnetisation is greater in a long bar than in a short one, because of the greater area afforded for air leakage, together with the more rapid ratio of decrease in the number of lines with regard to the length of the bar. The total magnetic resistance of the circuit thus diminishes as the length is increased. The fact that for very long bars the coefficient was found to be the same as for rings, appears to us simply to denote that the iron had in each case arrived at the straight part of the curve of saturation. Upon this point, however, the data supplied are not sufficient to enable a definite opinion to be formed. As regards short cylinders it was found that as the ratio of the length to the diameter diminished the mean coefficient of longitudinal magnetisation diminished very rapidly, and eventually became equivalent to the transverse. The coefficients were more nearly equal when soft steel was used, and much more so with tempered steel.

The Collapse of Overhead Wires.—The daily papers, as might have been expected, are publishing numerous letters from the public on the overhead wire question. The following letter from Mr. H. W. Tyler, which appeared in *The Times*, may be taken as a specimen:—"Sir: Anyone who walks about London to-day will see, if he diverts his attention from the slush in the streets, hundreds and hundreds of overhead wires which have succumbed, like the cedars and other trees in our gardens, from the effects of last night's snowfall. Both in the City and at the West End great has been the destruction. Broken and bent telegraph posts on the roofs, wires rolled up and put away in corners, with ends hanging or tied round railings or lamp-posts, are visible in all directions. Telegraph and telephone communication has been materially interrupted, in the metropolis as well as throughout the country. The expense of the reinstatement of these posts and wires will necessarily be considerable; and there will be the same liability to destruction when four inches of snow again falls suddenly. But the most serious part of the question is the danger to life and limb which is constantly incurred by the suspension of this constantly increasing network of wires over the heads of the hundreds of thousands of people who are constantly using the streets. There is, no doubt, a certain amount of temptation to allow, for the sake of cheapness, convenience, and profit, this danger to be continued, and it will be an uphill battle to fight before the happy consummation can be arrived at of burying these wires underground. But it will have to be done sooner or later, in this as in other cities, by the Post Office, the telegraph companies, and the telephone companies, as it has already been done to a great extent in some cities and by the Post Office here. The report of the recent Parliamentary Committee was not considered a success, even by some of those who were concerned in framing it. And, indeed, it is sufficiently obvious to all who are acquainted with the strength and durability of materials, with the tendency of wire to fly when stretched tightly and fractured, and with the weakness of the human frame to resist flagellation so administered, that serious and increasing dangers are the result of the present system. Unless, by pegging away, we can sooner cause the remedy to be adopted, we must wait till serious accidents and loss of life in high quarters have been occasioned, and then we shall, no doubt, be relieved from the birdcage existence to which we have now, for many years, been more and more trained."

The Repairs to the Telegraph System.—The work of repairing the damage done to the telegraphs by the recent snowstorm—the most disastrous storm which has ever occurred to the English telegraph system—is going on with great vigour, and the only important town which now remains isolated from the telegraph system is Portsmouth. North of that point communication has nearly everywhere been restored. The wires of the Submarine Cable Company have likewise been very much improved, and by the erection of lines to Beachy Head and Lowestoft the services with France, Holland, Germany, and Belgium have been reopened. Messages which cannot be sent to the Continent direct by either of these routes are forwarded by train to Dover, and telegraphed thence by the cables which remain intact. Among the companies, the Great Western is by far the heaviest sufferer. Over the greater part of this company's system the destruction of the wires has been complete, and nothing short of a permanent restoration is possible; while on other railways temporary wires have been erected. The Great Western Company have in these circumstances been granted the services of 100 Royal Engineers. As the railway companies are responsible for the efficient maintenance of the Government wires which are carried along their lines, the storm will involve some of them in considerable loss.

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When postal telegraph wires are erected on railways in England the Government supply the material, and the railway companies construct at the expense of the department, and afterwards, on an annual remuneration at the rate of 20s. per wire per mile, keep the service in efficient working condition. In ordinary times this payment yields profit to the companies, but it will be insufficient in several instances for the restoration which has now become necessary. To indicate the extraordinary pressure which was brought to bear on the telegraph wires during the late storm, it may be stated that on the main roads running to the south-west of England, a large number of A poles were not snapped, but literally dragged out of the earth and hurled with the wires over the edge into the fields. These A poles are the strongest which can be employed. The two sloping posts are sunk into the ground, and are firmly tied with wire. On no previous occasion have these poles been found unable to withstand the strain placed upon them. Although there has been a great demand for new poles, the stock in hand is sufficient for all requirements. Indeed, the department is so well provided for as to be able to offer to send a number of poles to the Great Western Railway, but that company, being equally fortunate in its reserve, was not called upon to accept the aid thus suggested.

The Employment of Spiral Springs for Measuring-Instruments.—In a paper by Prof. W. Kohlrausch, in the *Electrotechnische Zeitschrift*, on the employment of spiral springs for measuring-instruments and the accuracy of galvanometers constructed therewith, the causes which are likely to affect the constancy of spiral springs are mentioned in detail by the author, with an account of experiments bearing on each point, in order to afford some idea of the reliance that can be placed on the indications of instruments into the construction of which they enter. The effect of age, judging by observations on a brass spring extending over a period of seven years, may be completely neglected. Continuous and prolonged deformation produces a small amount of permanent set, so that the spring when released does not return to the original position, but does not actually alter the indications of the instrument if the readings are taken from the new zero thus found; steel is in this case less affected than German silver. Oft-repeated, but intermittent deformation—as exhibited by a spring of 90 convolutions and 2½in. long being stretched so as to change from a length of 3½in. to 9in., two hundred times per minute for four hundred minutes—introduced no appreciable alteration in its subsequent indications. An increase of temperature of 18° Fahrenheit raised the indications of a Siemens torsion galvanometer about $\frac{1}{10}$ per cent., so that the reduction in the elasticity of the spring is apparently almost equal to the decrease in the moment of the magnet, which would be, under these conditions, about 0·4 per cent. Further experiments on loaded springs confirmed this conclusion, and showed that steel was again to be preferred to German silver. By combining the results given above, the utmost limit of error introduced by the use of spiral springs cannot exceed 0·5 per cent. If, however, as is the case in the Siemens tension-galvanometer, the current passes through the spiral spring, care must be taken that the heating from the passage of the current is not excessive. The author found an alteration of 1·4 per cent. in the indication of such an instrument after 30 minutes continuous test, with a difference of potential of 100 volts between the terminals. If such instruments be calibrated at intervals to correct the decrease in the moment of the magnet, an accuracy within about 0·1 per cent. can be relied on, With the Siemens dynamometer for intense currents, the limit of error, owing to the friction at the mercury contacts, is about 1 per cent. Another form of instrument, the spring-galvanometer of F. Kohlrausch, is also reliable within 1 per cent., and is perfectly aperiodic with frictionless damping. Owing, however, to the employment of an iron core, the readings of currents taken in ascending and descending order of magnitudes will vary to some considerable percentage from the effect of residual magnetism, which exists in even the best soft iron, if this error be not eliminated by mechanically bringing the core past the position it would take up under the action of the current, and then leaving it free to return to that position.—*Journal* Inst. Civ. Eng.

New Application of Electrolysis to the Desilverisation of Lead.—The application of electrolysis to metallurgy is progressing with great rapidity, and we have no doubt that all dynamo manufacturers will before long find it necessary to design special plant for this purpose. According to the *Engineering and Mining Journal* a new process has been recently brought out in Germany for treating the argentiferous zinc crusts and skimmings electrolytically. "Heretofore, this alloy has most generally been worked further by distilling off the greater portion of the zinc it contains and obtaining a residual rich silver lead, sufficiently free from zinc to be submitted to cupellation. This distillation of a material consisting of over 80 per cent. of lead is a very troublesome operation, and though it is carried on with satisfactory results, still it remains the most difficult and expensive operation in the otherwise excellent process of desilverisation by zinc. The new process under consideration appears to offer many advantages that promise to make its introduction and adoption soon general. It is as follows: The zinciferous silver lead is first reduced to wheat size, and is then placed in a wooden vat, the bottom of which is covered with sheet lead. The vat is filled with an electrolyte liquor of sulphate of zinc, and a cathode plate of metallic zinc is suspended in the liquor at a suitable distance from the bed of alloy. This cathode is connected with the negative pole of a dynamo, the positive pole of which is connected with the lead bottom of the vat on which the alloy rests. By the action of the current, zinc is deposited on the cathode, and an equivalent portion of the zinc in the alloy is dissolved out. If this could be carried on till all the zinc was removed the process would be perfect, as all the zinc would be regained for use over again, and the residual silver-lead would be ready for cupellation. It is found that the amount that can be so dissolved out depends entirely on the surface exposed, the solution acting very slowly as the depths of the pores increase. When the electrolytic action becomes very weak and almost ceases, the bed of material is taken out, washed, and placed on the hearth of a liquating furnace. The exterior of the granules, being now entirely free from zinc, the silver lead is easily liquated down to the point where the unattacked alloy once more appears on the surface. The lead obtained from this operation is, of course, ready for cupellation. The residuum is once more granulated and replaced with fresh material in the vats, and subjected to electrolysis, until the lead again increases so far in proportion to the zinc as to make it profitable to again liquate it. In this manner, the two processes alternate, until the separation is complete. While at first sight this constant rehandling of the material appears to offer serious objections, still in practice it has proved much cheaper, both as to fuel used and in the increased saving of metallic zinc, than the distillation processes heretofore in use. By reducing the size of the grains as far as compatible with the circulation of the sulphate liquors through the mass, the number of times the alternating operations take place may possibly be reduced to two or at furthest three, and doubtless before long the strength or even composition of the bath will be so regulated that the whole process of dezincifying may be completed in one operation."

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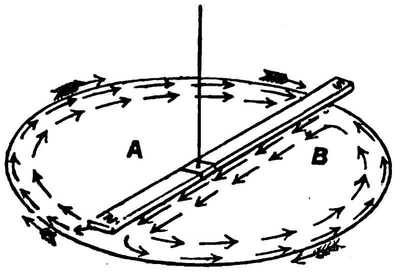
ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 165.)

It is clear that in Aragos's experiment the magnet can never turn at the same rate as the copper disc, for it is only when the disc is moving relative to the magnet that the lines of force are cut by the copper, and any current is generated in the disc. In the figure the winged arrows show the direction in



which the disc is rotating, and the unfledged arrows indicate in a general way the distribution of currents in the disc. The circuit marked A will attract the north pole and repel the south pole of the magnet, while the circuit marked B will act in the opposite manner, and hence the magnet will be compelled to follow the disc in its rotation. The universal tendency of induced currents is to destroy relative motion. Of course the magnet exerts upon the disc forces equal and opposite to those exerted by the disc on the magnet, thus tending to retard the disc. This means resistance to the action of the driving agent. If the couple exerted between the magnet and disc be determined, the product of this couple and the angular velocity of the magnet gives the rate at which work is done in maintaining the motion of the magnet. The product of the couple and the angular velocity of the disc gives the rate at which the agent has to work in driving the disc against the action of the magnet. The difference between these products—that is, the product of the couple and the angular velocity of the disc relative to the magnet—gives the rate at which work is done by the driving agent in maintaining the induced current in the disc.

Faraday conceived that a conducting circuit placed in a magnetic field is thrown into a peculiar state, which he called the *electrotonic* state, and that it is upon the changes of this state that induced currents depend. He frequently reverted to this idea. Faraday's electrotonic state consists simply of the number of magnetic lines of force which pass through the circuit (in the positive direction). As we have seen, the induced electromotive force is equal to the rate of diminution of these lines of force. If the circuit be a coil consisting of several turns of wire, we must add together separately the numbers of lines of force passing through each turn of the wire.

Bell's telephone, when employed as a transmitter, affords a simple illustration of the laws of induced currents. It consists essentially of a bar magnet, having a small coil of wire wound round it near one pole. In front of this pole is placed a thin iron diaphragm, which responds to the vibrations of sound. The terminals of the coil are connected with the circuit. When the diaphragm, in its vibrations, approaches the pole of the magnet, the lines of force pass more directly from the end of the magnet to the diaphragm, and consequently nearly all of them go through every turn of wire in the coil; but when the diaphragm is at a greater distance from the end of the magnet, the lines of force diverge more from the sides of the bar magnet, and some of the lines of force do not pass through every turn of the wire. Hence as the diaphragm moves there must be a current induced in the coil. This current passes along the line and around the coil of the receiving telephone, increasing or diminishing the magnetisation of the magnet according to the direction of the current, and thus causing the diaphragm of the receiving telephone to vibrate in sympathy with that of the transmitter.

When a current is started in a coil the current in each turn of wire causes lines of force to pass through that turn and through every other turn of wire in the coil. As the current increases the number of these lines of force passing through each turn of wire will also increase, and this must cause an induced electromotive force in every turn of wire, which will be in the negative direction with respect to the lines of force—that is, in the direction opposite to the current in the coil. These induced electromotive forces in the several turns will together constitute an electromotive force which opposes the battery, and the current flowing in the coil will be determined by taking the difference between the E.M.F. of the battery and the induced E.M.F., and dividing this difference by the resistance of the circuit. Of course the induced electromotive force must always be less than that of the battery, and so much less that the current is increasing, for otherwise the cause of the induced electromotive force, viz., the increase of the current, would cease. The result of this action, which is called *self-induction*, is to cause the current to increase steadily instead of suddenly, and to take some time before it attains its final value, as determined by the E M.F. of the battery and the resistance of the circuit.

Similarly, when the current dimishes the number of lines of force passing through each turn of wire will diminish, and there will be an electromotive force generated in the same direction as the current and tending to prevent its decrease, the measure of this induced electromotive force being equal to the rate of diminution of the number of lines of force passing through the circuit. Hence, it is clearly impossible for a current in a coil to cease suddenly, for this would entail an infinite electromotive force in the direction of the current. By breaking the continuity of the coil and rapidly separating the ends of the wire an enormous resistance can be very quickly thrown into the circuit and the current very quickly stopped, but this causes a very great electromotive force to be induced, which compels a current to pass for some time across the gap, though the current must, of course, diminish very rapidly, as otherwise there would be no induction. The presence of an iron core in the coil very much increases the self-induction. The effect of self-induction in the phenomena of electric currents is, in some respects, similar to that of mass in ordinary dynamics. It requires a finite electromotive force to act for a finite time to produce a finite change in the strength of a current. But it should be noticed that the self-induction does not depend simply on the strength of the current and length of the conductor, but also on the configuration of the conductor. A coil of wire has a very much greater self-induction than a straight wire of the same length, and the more closely the several turns of wire are brought together the greater is the self-induction.

Again, an amount of work proportional to the square of the strength of the current has to be expended in starting the current, and this amount of work must be performed by the current before it can cease. In this respect, too, the self-induction of a conductor resembles *mass*, the energy expended in starting the current and possessed by it, or by some invisible mechanism connected with it, being analogous to the kinetic energy developed in a moving mechanical system. It is therefore impossible to instantaneously generate a finite current in a conductor, just as it is impossible to instantaneously generate a finite velocity in a portion of matter, because no agent can work at an infinite rate or exert an infinite force; and in the same way it is impossible to instantaneously destroy a finite current. But the rate at which a given electromotive force can generate a current depends on the form as well as the length of the conductor, for the self-induction of a coil is very much greater than that of the same wire when straight; and this suggests that the energy is to be sought for, not so much in the conductor itself in which the current is flowing, as in some mechanism external to the conductor and intimately related to it—a mechanism, in fact, by which the several parts of the wire are connected together and upon which every element of the conductor conveying the current acts. Clerk Maxwell identified this mechanism with the luminiferous ether, and the motion to which the energy of the current is due with a rotatory motion of the particles, or "cells," of the ether. The stresses introduced in the elastic substance of these cells by the rotatory motion he identified with magnetic force.

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According to this system the energy of an electric current is to be looked for not, in the conductor in which it flows, but in the whole of the surrounding space to which its magnetic influence can extend.

Faraday investigated the phenomena of self-induction, his attention having been called to the subject by Mr. William Jenkin, who noticed that when he broke the circuit of his electro magnet, holding the extremities of the wire in his hands, he received a sharp shock, although the battery itself was unable to send any appreciable current through his body. The separation of the ends of the wire introduced a resistance of several thousand ohms into the circuit, and this, of course, produced a great diminution of the current. The diminution of the current caused an electromotive force to be induced in the coils of the magnet tending to sustain the current, and this E.M.F. was many times greater than that of the battery. It was, therefore, capable of sending a current through the body of the operator much greater than that which the battery alone could produce, and this instantaneously produced a shock. The induction current, though much greater than that which the battery could send through the circuit with its increased resistance, was, of course, very soon much less than that which the battery had sent through the magnet alone, for it was not till the current began to diminish that the induced electromotive force came into existence.

Induction currents are generally of very short duration and vary very much while they last. They, therefore, cannot usually be measured as currents, though it is possible to measure the total amount of electricity which passes during the whole time that the current lasts—that is, to measure the amount of the electric *discharge*. In this respect induction currents resemble those mechanical forces, generally known as impulsive forces, which cannot be measured as forces by the *rate* at which they generate momentum, though their impulses can be measured—that is, the whole amount of momentum which they generate while they last.

Def.—The coefficient of induction of one coil upon another is the electromotive force which appears in the second coil when a current is being increased at unit rate in the first.

Thus, if a unit current were generated in the first coil in one second, starting from nothing and increasing uniformly, the electromotive force in the second coil, which would be constant during the second, would represent the coefficient of induction.

Hence, the coefficient of induction of one coil on a second is equal to the number of lines of force which pass through the second coil when a unit current flows in the first.

It can be shown by calculation in simple cases, and experimentally in all cases, that the coefficient of induction of one coil upon another is equal to that of the second on the first. Hence, this coefficient is called the *coefficient of mutual induction of the two coils.*

Def.—The coefficient of self-induction of a coil is the number of lines of force which pass through the coil when a unit current is flowing in the circuit.

(To be continued.)

INCANDESCENT LAMP MANUFACTURE.—IV.

BY J. SWINBURNE.

Amyloid Carbon. (*Continued.*)

Sulphuric acid may also be used for acting on paper, so as to make material out of which flat carbons may be cut. Parchment paper may be bought ready made, and it would scarcely be worth any lamp maker's while to make it himself. It is generally used for covering preserve jars, and for book binding; and the quality used for these purposes is thin. If it is wanted thick it can be readily obtained wholesale in the City.

Having obtained the parchment paper, the next thing is to cut it up into slips which, when carbonised, shall all have the same surface when the length is the same.

It will be convenient now to describe the processes available for all carbons cut from sheets, not only of sulphuric acid parchment paper, but from amyloid made by any method, or from sheets of any material that can be cut.

Lamps have practically always carbon loops, and if these loops are flat strips of carbon they may either be cut in straight slips, and these slips may then be bent over, so as to make a loop like that of a sugar tongs; or the loop may be cut flat out of the material, so that it does not need to be bent over, thus making a flat loop like that of a horseshoe.

Cutting these strips is, as has already been stated, a very difficult matter. The best way of cutting the sugar-tongs loops is to fasten a sheet of the material round a mandrel, and then screw-cut it with a very sharp tool. Parchment paper unfortunately takes the edge off a steel tool very quickly. The same thing may be observed in working up vulcanised fibre for insulating purposes. The sheet of parchment paper should be overlapped, so that the result is a long tape of parchment paper of uniform breadth, with joints every here and there. The mandrel should be of large diameter, so that there is a fair length between each joint, otherwise there will be difficulties in carbonising. To carbonise such strips they are wound on frames, and if the length from joint to joint in the strip is not an exact multiple of the distance round the frame, the joints will come in the wrong places. It is best, therefore, to have as few joints as possible. The carbonising frames should be filled as soon as the strip is cut, as otherwise the strip is apt to curl about and twist, as it absorbs or gives out moisture unevenly. Of course the carbons may all be cut separately, a sheet of parchment being used which is just long enough to allow a reasonable margin. Instead of pasting the overlapping material so as to screw-cut it into a continuous, or rather, a jointed strip, the overlapping part may be on a flattened part of the mandrel. This gives a sheet with a number of parallel cuts, which do not reach the sides; and the sheet can be bent over a carbonising block. In practice, however, all the little flat loops do not lie nicely, but one gets under the other on the carbonising block, and the outer ones get stretched or broken. The same sort of sheets may be got by mounting a sheet of the material on lead on the table of a slotting machine. The slotting head has a tool like a broad plane iron, and the lead is fed under it. When it is remembered that the strips must be about four inches long, and only a fiftieth of an inch broad, the difficulty of cutting a number all alike may be realised. A difference of half a mil., or one two-thousandth of an inch, will affect the resulting lamp. The writer has not had much experience in cutting carbons for sugar-tongs loops.

Horseshoe loops are cut by means of punches. Weston punches or cuts a long wavy carbon out of a flat sheet of what he calls *tamidine.* This wavy strip has broader ends for mounting, and perhaps to secure uniform length, with the object of thus getting uniform surface. The punch is probably made in two pieces fastened together, and is probably arranged like those used by fancy stationery manufacturers. The wavy strips are bent over, keeping the flat ends in the same plane, thus getting a wavy loop. The strip turns through a right angle in each leg, so that the top of the loop bends as a sugar-tongs loop, though the rest of the strip is as in a horseshoe loop. The great drawback to such a form as this is the difficulty in testing it. The light emitted in any direction has no definite relation to the whole of the light given by the lamp. In testing a flat carbon lamp the ratio of the measured light to the whole spherical emission can be got when the dimensions of the carbon are known; but in Weston's lamps this cannot be done. The plan of leaving thickened ends on is also bad. In the first place, if the surface per inch of carbon does not come quite right the error in the lamp cannot be corrected by using a slightly shorter or longer carbon. In the second place, the thickened ends always contain occluded gases, which can only be got out with difficulty on the pumps.

Maxim used M-shaped paper carbons, which were beautifully stamped. They were probably made with a kind of stationers' punch. The lamps were about 30 candle-power at ·25 candle-power per watt, and the carbons were broad; otherwise there would have been difficulty in making the punches.

The best way of punching very long and narrow carbons is the double method. A blank is first punched out. This blank is then placed in another press, and a similar blank very

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slightly smaller is removed from the centre. A long narrow carbon is thus left. A broad cross-piece is left at the end so as to hold the finished blank, and to keep the ends of the carbon in the right position during carbonisation. Tools for such purposes as these must be very carefully and accurately made. The presses have to work very accurately. The writer used fly presses, such as used for brass work, but very carefully made. The die—that is to say, the part with the hole—is made of hardened steel, and the punch is soft. The punch is made just a shade too large, and is then mounted in the press and driven into the hole. The die takes off a minute cut all round, and leaves the punch an exact fit. The punch will then cut the finest tissue paper with ease. It soon loses its edge. The edge is therefore turned out a little with a burnisher, and the punch again driven into the die. Soon the burnisher is of no avail, and a hammer and round nosed punch must be used. If the die loses its edge it is sharpened by means of a small oilstone. The second punch and die are similar, except that they are smaller. The die has a brass guide piece to hold the blank exactly in the right position. The fly presses must have stops, so that the punches cannot be raised high; even with stops, a persevering girl will get her finger tip under the punch. In punching amyloid carbons two presses must be used, for the blanks curl about, and the least alteration of shape between the first and second punchings is fatal. It does not do, therefore, to punch a quantity of blanks one day, and then change the dies and punch the centres out of them next day.

Lane-Fox, as already mentioned, used vulcanised fibre as material to carbonise. Vulcanised fibre does not appear to be perfectly homogeneous. If a thick piece is carbonised it will be found to split up into flakes, showing that the material is made up of numbers of thin sheets stuck together by being partly gelatinised. Mr. FitzGerald has also patented zinc chloride carbons.

Parchmentising by means of zinc chloride is much more difficult than by sulphuric acid. No directions seem to have been published that will enable anyone to make carbons by zinc chloride solution. Mr. FitzGerald's solution does not give good results. If the writer's memory is not at fault, Mr. FitzGerald's is the Irish specification, which says the inventor takes a hot solution, which he prefers to use cold.

The best method of making thread carbons by zinc chloride is to use a strong solution. The ordinary stick chloride may be shaken up with water till a saturated solution is obtained. This may be diluted with about 10 volumes per cent. of water. Zinc chloride solution does not behave quite like sulphuric acid; for if sulphuric acid is too strong it acts on the cotton too quickly, and turns it into dextrin, but strong zinc chloride solution does not act on cotton. There appears to be one strength at which cotton is soluble in the cold, but it is very slowly acted upon. It is therefore better to use the solution stronger than this, and to pass the thread through it and then leave it on a tile exposed to the air. If the thread is watched it will be found to absorb moisture from the air and gradually to become transparent. After a time it will be so liquid as to begin to run. If the tile is now held under gently running water, the zinc chloride will be washed out, leaving an amyloid thread like that prepared by sulphuric acid. If the zinc chloride solution was too strong to start with, it will absorb too much water before the cotton is attacked, and the thread will be turned into an uneven flat strip. If the solution was too weak the cotton will not be acted upon at all.

Stick zinc chloride contains zinc oxide, formed when it was fused, and this may have some deleterious action. The oxide of zinc is soluble in the chloride. To obtain chloride free from oxide, granulated zinc is dissolved in dilute hydrochloric acid, excess of zinc being present. When the acid is quite used the dilute solution is filtered, and then concentrated by evaporation. The solution made this way is quite clear, while that made from the fused chloride looks chalky.

The writer finds the solution of zinc chloride in hydrochloric acid gives much better results. Zinc chloride dissolves freely in hydrochloric acid, with great evolution of heat. As the heat causes copious fuming, the chloride should be added a little at a time, till a saturated solution is obtained. This is then diluted to about 1·745, and the thread is drawn through, and then exposed to the air, as in the case of the aqueous solution of zinc chloride.

A solution of zinc chloride in equal volumes of hydrochloric acid and water acts very well also. In fact the aqueous solution of fused zinc chloride will be found very much the better of the addition of enough strong hydrochloric acid to clear it.

It is generally advisable to boil the cotton in a solution of borax before use in these amyloid processes, as that seems to remove traces of grease or resin, and to make the cotton more absorbent. Of course it is dried again.

Chloride of zinc does not destroy the fibre of the cotton so well as sulphuric acid. How far it is really necessary to destroy the fibre it is difficult to say. Thread still distinctly showing the twist of the cotton sometimes makes good lamps; but carbons made of such material writhe round when the lamp is lighted, and go back again when it is switched off. Zinc chloride allows a closer twisted thread to be used, as it has plenty of time to soak into the interstices before the fibres begin to swell and gelatinise.

Paper may be treated with zinc chloride solution. Loose textured blotting paper is good, but Swedish filter paper is better. A sheet is dipped, and allowed to soak thoroughly, and then laid on glass to gelatinise. When perfectly clear the sheet is washed thoroughly; it will float off the glass. It is not easy to dry these sheets so as to get them flat, as they get distorted during the washing and dry wrinkled. It is then impossible to stamp the blanks out. Vulcanised fibre can be got very thin, but it does not make good carbons. Probably it is not thoroughly devoid of fibre.

It is hardly necessary perhaps to caution anyone as to the use of hydrochloric acid solutions of zinc chloride. They give off great quantities of hydrochloric acid, which is exceedingly bad for the lungs.

The solution of zinc chloride acts more strongly when hot, but it also has a much greater tendency to convert the cellulose into dextrin. An aqueous solution of zinc chloride of sp. gr. 1·86 – 1·9 acts on cellulose at the temperature of boiling water; but a little extra heating will convert the jelly into a thin liquid. It is difficult also to get rid of the last traces of fibre.

THE PHYSICAL PROPERTIES OF MANGANESE STEEL.

At the last meeting of the Royal Dublin Society, on 15th December, Prof. Barrett, of the Royal College of Science, Dublin, read a paper on the above subject. Prof. Barrett pointed out that Mr. J. T. Bottomley had sent a brief note on the non-magnetic character of manganese steel to the Aberdeen meeting of the British Association, and had kindly furnished him with a specimen of this steel, and the name of the makers and patentees, Messrs. Hadfield and Co., of Sheffield. The steel contains 12½ per cent. of manganese. Through Messrs. Hadfield, Prof. Barrett had obtained wire drawn from manganese steel, a process that first presented great difficulties, but was ultimately accomplished with ease by heating the steel to whiteness, and quenching in cold water after every reduction through two sizes. Sudden cooling softens this steel; slow cooling hardens it. A No. 19 wire (diameter 0·98 millim.) was thus obtained of two kinds—hard and soft; the density was 7·708. The electric conductivity was found by Prof. Barrett to be very low. The No. 19 wire had a resistance of an ohm per metre, the specific resistance in C.-G.-S. units being 77,000 for 1 cubic centimetre; ordinary iron wire is only 9,800, and German silver 21,170; so that a use might be made of manganese steel for resistance coils in electric lighting.

The magnetic character of this steel was then carefully tested by Prof. Barrett. Mr. Bottomley found the intensity of magnetisation of this steel, after submitting it to the most powerful magnetising force, was 2·55 in C.-G.-S. units, or the magnetisation per gramme was 0·013 in C.-G.-S. Ordinary steel gives a number varying from 40 to 90, and even 100 C.-G.-S. units per gramme. So that if ordinary steel of average quality be 100,000, manganese steel is 20.

This represents the permanent magnetism. Prof. Barrett,

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by different methods, has determined the susceptibility, that is, the induced magnetisation, in a uniform field. Compared with iron as 100,000, manganese steel was found to be 300. In fact, it is very wonderful to find no sensible attraction exerted on this steel by the most powerful magnetic field that could be obtained.

Hence, as Prof. Barrett suggested in his paper, its use for the bed plates of dynamos and the plating of iron vessels is obvious. Ships built of such steel would have no sensible deviation of the compass. As excellent castings can be obtained from this steel it ought to have many other applications from its extreme hardness.

Dr. Hopkinson's experiments on the magnetic susceptibility of manganese steel were referred to by Prof. Barrett, who mentioned that he had only seen them after his paper had been written. Though Dr. Hopkinson's method of experiment was wholly different, his result is fairly in accordance with the numbers obtained by Prof. Barrett for the ratio of iron to manganese steel.

Prof. Barrett determined the tenacity of the manganese steel wire. The hard wire had the extraordinary tenacity of 110 tons per sq. inch, or 164·5 kilos. per sq. mm., a number confirmed by independent tests which the chief engineer of the Great Southern and Western Railway Works (Mr. Ivatt) had kindly made for Prof. Barrett. Ordinary steel is only 99 kilos. per sq. mm., pianoforte steel wire alone showing a higher tenacity. The soft manganese steel wire had a tenacity of only 48 tons per square inch with an elongation of nearly 20 per cent.

The modulus of elasticity was also determined by Prof. Barrett by direct stretching. It was even lower than wrought iron, the mean number for the hard manganese wire being 16,800 kilos. per sq. mm., the soft manganese wire having a still lower modulus. The modulus for ordinary steel wire is 18,810, and for iron wire 18,610; so that though hard manganese steel has an enormous tenacity, it "gives" more than steel under sudden stress, of course recovering itself if the limits of elasticity are not passed, a property most useful for certain purposes.

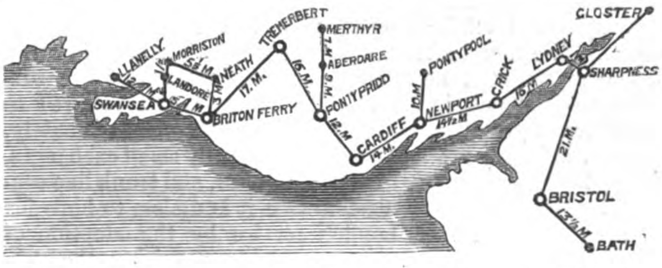
Further experiments on this interesting material are in progress in the Physical Laboratory of the Royal College of Science, Dublin.

THE TELEPHONE IN THE WEST OF ENGLAND.

The Western Counties and South Wales Telephone Company commenced operations, as an offshoot of the United Telephone Company, in the year 1878. The district over which it is exclusively licensed to make use of the patents of the parent company comprises the counties of Somerset, Gloucester, Hampshire, Wilts, Dorset, Devon, Cornwall, Worcester, Hereford, Monmouth, and the whole of South Wales. An exchange was opened at Bristol in the month of March, 1879, with 25 subscribers. The number of subscribers upon the list at the time of a visit which we recently paid to the exchange was 380, in addition to which a number of private lines have been erected in this city. It was not until five years later that the company extended their operations to other parts of their district, but within the last two years very rapid progress has been made, as will be evident from the following table, showing the present position of the company's operations in the nine towns in which they are now represented :—

Exchange.	No. of subscribers connected.	Daily calls	Average per subscriber.	Date of opening of Exchange.
Bristol	380	2,533	6·6	March, 1879
Plymouth	126	475	3·7	February, 1885
Torquay	50	69	1·3	August, 1885
Portsmouth	88	321	3·6	July, 1885
Cardiff	29	149	5·1	November, 1885
Bournemouth ...	89	146	1·6	March, 1886
Southampton ...	35	140	4·0	June, 1886
Swansea	18	17	0·9	August, 1886
Bath	13	25	1·9	November, 1886

At the same time the company wisely decided to turn their attention to the question of inter-urban, or long distance communication. Having obtained the necessary licenses from the Postmaster-General, it was determined to go in at once for a comprehensive scheme which should place the whole of the South Wales mining district in communication with the seaports of Swansea, Cardiff, and Newport, and these in turn with Gloucester, Bristol, and Bath. The accompanying sketch map



shows the course of this system of trunk lines. This extensive undertaking was nearing its completion, and the lines would have been opened throughout early in the present year, but we regret to learn that the disastrous storm of Dec. 26th has inflicted some damage to the wires, and the date of opening will have to be postponed for some little time.

In addition to this system another almost equally extensive is projected in the south. This network will have Salisbury for its centre, and will extend a series of radial wires to the towns of Winchester, Southampton and Portsmouth, Bournemouth and Poole, Dorchester and Weymouth, with probable further extensions westward, and a main trunk to Bristol. The scheme will be proceeded with in the course of the summer. Further plans have as yet hardly been definitely formulated. It is, however, hoped to establish a third network in the counties of Devon and Somerset, and then to connect this with Bristol and Salisbury, and eventually, if possible, to place the whole in communication with London. Some experiments which were recently carried out upon the Great Western Railway lines on a Sunday morning, when the telegraph traffic was very light, showed that, even under the unfavourable conditions of an iron wire and an earth return, it was possible to speak from Exeter to London without much difficulty, while between Bristol and London the communication was quite satisfactory.

Returning to the work already carried out, the following short trunk lines are in actual operation :—

Bristol and Bath........................	13½ miles.
Cardiff and Newport	14 „
Bournemouth and Poole	6 „
Swansea and Llanelly	12 „

In addition to which a line of 8 miles from Worcester to Great Malvern, and one of similar length from Weymouth to Dorchester, will very shortly be ready.

The total length of the South Wales trunk line from Bristol to Llanelly is 128½ miles, the respective distances from Bristol of the chief places on the line being as follows :—

Sharpness Docks	21 miles.
Gloucester	39 „
Newport	52½ „
Cardiff	66½ „
Pontypridd................................	78½ „
Treherbert	94½ „
Briton Ferry	111½ „
Swansea	116½ „
Llanelly	128½ „

The Newport and Cardiff line, which was the first to be erected, consists of a solid galvanised iron wire, No. 11 B.W.G., having a resistance of 24 ohms, and a weight of 200lb., to the mile, with a breaking strain of 520lb. The later trunk lines are all built of hard-drawn copper No. 14 B.W.G., having a resistance of 8·28 ohms, with a weight of 110lb. per mile, and a breaking strain of 360lb. For the local lines (in addition to the last-named) three classes of wire are now in use, No. 15 hard-drawn copper, No. 17 silicium bronze, and a 3-strand No. 16 iron wire.

It may be mentioned that the gross rental of the company now approaches £14,000 a year, and shows an increase of about

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£4,500 during the last twelve months. This satisfactory state of things is due, in a very large measure, to the great energy and determination displayed by Mr. H. F. Lewis, the secretary and general manager of the company. But Mr. Lewis has not only succeeded in bringing the financial affairs of the company into a sound and progressive condition, he has also introduced certain improvements into the working of the Bell switch-board which render the Bristol exchange one of the most rapid and efficient which it has ever been our lot to inspect. We found after several careful timings that fourteen seconds represented the average interval required for a subscriber to get "put through." The improvement referred to is a matter of *procedure*, and not of appliances. Unfortunately, however, it is only available for comparatively small exchanges, where all the lines are carried to one board, and trunk line connections are not very frequent, so that it is useless to hope for any improvement in the London service by the adoption of this plan. The improvement consists in requiring the subscribers to give *their own* number as well as that of the connection required. By this simple device it is never necessary for the "board operator" to speak to the "table operator" at any time, except in the event of a wire asked for being already engaged. At the Bristol exchange there are three board operators at work, each with two tables placed close behind her, and the sole communication which passes in the room for each connection made is the announcement of the figures representing the number asked for by the subscriber. Of course, the table operators have to speak to the subscriber, but at the time of our visit, although the annunciator drops were falling fast and furiously, yet the room gave one the impression of perfect quietude in comparison with the switch room of an average telephone exchange in this country.

Having regard to the efficiency of the service it is not surprising that the telephone is very popular in Bristol, even among those who have not as yet availed themselves of the service, although there is plenty of room in a city of 200,000 inhabitants for at least ten times the present number of subscribers. We may add, in conclusion, that all the fire stations and many of the cab rests are connected with the exchange, and that the Watch Committee have under consideration a scheme submitted by the chief constable for erecting a system of police call boxes throughout the city.

THE "UNION" STORAGE CELL.

Under the above name, the "Union" Electrical Power and Light Company are introducing a new type of secondary battery. So far as we have been able to form an opinion from a careful inspection of the cell and our knowledge of the properties of the material which forms the cathode, we venture to prophecy an important future for this battery. The cathode consists of a solid slab of peroxide of lead, which is so prepared as to assume a highly coherent form, in which, moreover, it is an excellent conductor of electricity. At the same time the slab has a sufficiently porus texture to present a very large effective surface. Contact is made with the electrode by means of a slip of platinum foil, over which is laid a thin strip of celluloid, the whole being secured to the surface of the peroxide by means of two bolts of insulating material. Owing to the conducting power of the peroxide and its solid condition no lead supporting plate is necessary, and hence there is no tendency to buckle or to short circuit. The positive element consists of a slab of spongy lead. In order still further to increase the output for a given dead weight, internal cells made of celluloid are employed, which are placed in plain wooden boxes. The result is that according to the statement of the company a capacity of 5 ampere-hours per lb. of total weight has been attained. This is a very marked advance, and should render the battery well suited for use with miners' safety lamps, as well as for heavier work, where a portable battery is required, such as for tramcar and torpedo boat service. A further advantage obtainable by the use of this particular type of cathode is that *both* plates may be removed from the cell, and may readily be transported to any required distance for recharging. The company therefore proposes to supply batteries for electric lighting upon the system of removal for re-charging. It is, moreover, pointed out that as the peroxide plates may be stored in the dry state, a third set of plates ready charged may be kept always at hand, so that in the event of any abnormal discharge the installation will not be dependent upon the punctual removal of the plates.

DEATH OF SIR FRANCIS BOLTON.

It is with profound regret that we have to announce the sudden death of our much esteemed fellow worker Colonel Sir FRANCIS BOLTON, who expired late on Wednesday night at the Bath Hotel, Bournemouth, where he had been staying for the last two months in the hopes of being cured there of a malady which he, at all events, never appeared to regard as of a very serious character. His loss will be profoundly felt, not only among his personal friends, who are exceedingly numerous, but by the scientific world, on whose behalf he was an indefatigable worker and staunch patron. Sir FRANCIS was publicly known, more particularly as Water Examiner for the Board of Trade, a post which he has held since 1871, and as the contriver of the illuminated fountains at South Kensington annual Exhibitions, a work which was under his personal supervision to the last. But the electrical world will remember him best by the part he played in founding the Society of Telegraph-Engineers, to which he has rendered many valuable services, and of which he has been the honorary secretary all through its career. As a sample of his industry and the intelligent interest he took in electrical inventions we have only to refer the reader to the remarkably exhaustive abstracts of electrical patents in the papers he contributed to this society. Sir FRANCIS BOLTON entered the army in 1857, and was the inventor of the visual signalling system which now prevails in Her Majesty's service. He has been on the retired list since 1881, and died at the early age of fifty-six. From an obituary notice which appeared in the *Globe* last night we extract the following:—"Sir Francis had for a long time past been an acute sufferer, the symptom of his disease which gave most trouble being an almost total loss of voice. In the hope of improving his condition he underwent several operations, but with little result, and experienced considerable pain, notwithstanding which he invariably appeared in the best of spirits, and frequently made jokes at his own expense in reference to his loss of voice. Sir Francis was in appearance of somewhat burly build, and had a fine presence. He was exceedingly popular with all who came in contact with him, and his bearing towards his *employés*, even of the lower grades, was such as to render him exceedingly popular with them also."

CORRESPONDENCE.

WAS IT UNDULATORY?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your comments on page 161 on the make and break transmitter invented by Messrs. Dann and Lapp, you rightly observe that if there is self-induction in the circuit, however abrupt the make and break may be in the transmitter, the current in the receiver will still be of an undulatory character. That is indisputable, and it therefore follows that, even on the supposition that Reis's telephone was to be used as a make and break instrument (though he never said that such was the case), he used currents of an undulatory character in his early instruments. This is the very point on which the American judges have been hopelessly and wilfully misled by the wily and unscientific theories of 'cute Yankee attorneys. Not one of the United States judges understands anything about self-induction, or they would see that even a make and break transmitter pure and simple must produce an undulatory current such as Reis required and Bell claims to have been the first to have invented.—Yours, &c., ALPHA.

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THE VALUE OF TELEGRAPHIC COMMUNICATION IN TIME OF WAR.

Sir James Anderson contributes the following letter on this subject to the January issue of *Imperial Federation*:—

SIR: In your editorial remarks in the December issue upon my letter about Cables, Colonies, and Commerce, you suppose me to mean that the two latter may be "shelled and smashed" if the cables are cut.

It is, I admit, not a pleasant thing to say, but if it is the truth it had far better be said, and I think it cannot be too strongly insisted upon, that it is folly to depend upon submarine lines, *laid in time of peace*, and projected as they all are upon the charts of all nations, remaining intact in time of war.

It is reasonable enough to rely upon such conditions until war is about to be declared; but whenever that time seems near then I do assert very positively that a dozen Alabama-like craft can be very quickly made ready to cut as many cables as may be desired.

For cutting purposes it is not necessary to think of long distances or employ large vessels. The ships destined to cut can select their own place and time, and it is just as easy to go to a given latitude and longitude, out of sight of land, where a cable is known to be lying, *and find it*, as it is to go to any distant headland or lighthouse.

You say you are quite content to have the issue raised upon the question of the "*time when*" other cables should be laid, and you "advocate having two strings to our bow at once, so as to be ready when war is imminent."

My contention is that laying cables from Vancouver to Sydney, or the Cape to Australia, is more accurately described as a fifth wheel to the coach than as two strings to the bow. When laid their position will be known, and they can be found and cut by any one so disposed.

I have, in a paper read before the Delegates of the Chambers of Commerce, at the Colonial Exhibition, given my views of the only conditions which offer any alternative to this statement, and I do not believe any one familiar with the subject will gainsay what I have advanced. Briefly, I put it thus:—

The enemy must realise that it is no use cutting cables, because there are so many other routes through neutral countries by which telegrams can be sent, that to interrupt the communication would only create an unimportant inconvenience, and would not affect the result of a campaign. There may also be cables owned by nations who are no parties to the quarrel, and who are strong enough to demand that their cables shall not be cut; and all nations may now feel assured that strategic cables laid, when required, in a position not known to the enemy, will form part of the equipment of any naval power engaged in hostile operations. I should be very glad if I could think of any protection for cables other than I have already defined in this and in my letter in your December issue.

At the risk of presuming too much on your space, I should like to state what I believe will be the position of our commerce, coaling stations, and colonies, when war is about to be declared between this country and any other possessing a fleet of cruisers.

Our shipowners will insure if they can—paying for war risks.

All sailing ships must either sail under neutral flags or be laid up in dock in the safest port they can reach. All steamships continuing under the national flag will be informed by the Admiralty of the track they must follow, and the given latitude and longitude where they will find our cruisers or other war ships.

An inevitable feature of every plan for the protection of our commerce will be the *restriction* of our commercial marine to our fastest steamers and the *concentration* of our war ships and cruisers—and I pray the latter may be belted, for such craft as the "Iris" or "Mercury," "Etruria" or "Alaska," have only one chance if struck by a shell—which is, that the shell may go through both sides and into the water before it explodes, or the gun deck will be a shambles. I can suppose such craft acting as eyes to the fleet, and we may hope that their superior speed will enable them to return to our fighting squadron before they are attacked by an enemy's war ship; and they may lure the foe to a position in the open sea where a battle can be fought with perhaps some advantage to our fleet.

It may be supposed also that they would count for a good deal with an enemy who had few or none so good; but it is for keeping open communication, for the transport of troops and stores, that they will be chiefly valuable.

I do not believe in merchant steamers being reliable war ships, and I am as disappointed when I see such ideas advanced as I am delighted when I read of the launch of another belted cruiser.

I cannot believe those responsible for the defence of our Empire are not prepared to provide all coaling stations with such means of defence and weapons for offensive warfare as will ensure the flying squadron of the enemy a warm reception. It would be an insult to our Admiralty and War Office to suppose that they are relying upon either our war ships or cruisers to be insufficient force at more than a few of our principal coaling stations at one time to meet any considerable enemy. To follow an enemy is to exhaust the coal supply, and to concentrate a number of ships by telegraph is certain to bring some of them to the desired spot with their coals exhausted; then, if they cannot get a fresh supply because of the strength of the enemy, they will easily be "nursed" and captured.

We shall probably know where to look for the enemy, and especially we will seek him at his coal-supply rendezvous, and endeavour to keep him there or capture him; but to do this effectually our own coaling stations must be in a position to guard themselves against a surprise.

The same must be said of all our colonies, and I feel I am only writing what is well understood by those who are responsible, but I cannot help seeing how very imperfectly the position is recognised by the public. The concentration of our fighting power upon a well-matured plan, with as little necessity as possible for spreading out in distant oceans, must be the very essence of any arrangement. Coal supply and coal endurance will be the test of naval supremacy.

Then as to commerce, it goes without saying that from the moment war apprehensions are in the air, all engaged in financial transactions will restrict their engagements to the utmost. They will not trust to cables, but prepare beforehand for the worst.

Very little will then depend upon the Mediterranean cables. We can get to the shores of that sea through Spain, France, Italy, Austria, Greece, and Turkey, and if we cannot with our naval resources keep fast cruisers to cross the Mediterranean to Egypt, then indeed we shall be engaged in a terrible and calamitous war, and what commerce there is will be carried to and fro under other flags. But I for one do not think that day is very near.

At all events the long submarine cables proposed will do nothing at all to diminish the danger (which is the only point of difference between us, in your opinion).

I maintain, then, that the "*time when an alternate line should be laid to meet the exigencies of war*" is only *when* we have determined with whom we are going to war, and where we are going to fight him. Much, very much, can then, and in anticipation, be done to ensure communication, but the very worst plan of all is to lay long, expensive submarine cables in the deepest oceans, in which it is almost impossible, and always tedious and costly, to effect repairs when the cables are old, or have been cut or broken.

Better far use the money to reduce the tariffs, thereby increasing our commerce and adding to the wealth of the whole Empire, which is one of the best preparations for war, and will do more for Federation than any other scheme which has yet been or, I believe, can be formulated.

Upon this letter the Editor makes the following remarks:—

A New Pacific Cable Route to Australia.

Sir James Anderson has returned to the subject of ocean cables in a letter which we publish in another column. Since our last issue the matter has practically passed the stage of argument, and it is therefore unnecessary for us to follow it up further. We are glad to hear that a powerful company has been formed, with a capital of £2,000,000, to establish a telegraphic line between the Australasian colonies and Vancouver. This will spare us the necessity of further allusion to the weak places in our communications, which will soon be doubled in strength and efficiency by the possession of an alternative route.

Sir James Anderson's letter is interesting, as giving the opinion of an experienced man upon the probable results to our commerce of an outbreak of hostilities with another Power. His suggestion that neutral lines of telegraph would be available opens the field for some nice questions as to the laws of international neutrality in time of war. But where are these neutral lines? If any agreement could be arrived at to neutralise all cables, the case would be different, but there does not seem much prospect of this, and at present there is but one route to Australia. We want to see *two*, and we shall not be kept waiting long for the event.

As for the proposition that the time for laying an alternate line is "only when we have determined with whom we are going to war, and where we are going to fight him," we really cannot understand it at all. What we want is to make certain of being able to flash out the instructions to every port in the Empire, "Lay down your mines," the moment the hostilities are imminent. No one can gainsay the vital importance of having this power. No one can reasonably deny that, whether cable-cutting be easy or difficult, the possession of two routes gives a twofold chance of forwarding intelligence that may save millions of pounds' worth of property from destruction.

We believe that a Pacific cable route would, in fact, do more than double our chances, because we have no great faith in any foreign squadron being found on the high seas so far from port, if war with England was expected. But admitting one route to be no more secure than another, the mere numerical addition to our possible means of communication would well deserve all the support that can be given to it, and the safety of the Empire emphatically demands that the addition be made without delay.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

CONTENTS.

Notes ... 181
Elementary Electricity and Magnetism—II. (Continued.) Illustrated ... 186
Incandescent Lamp Manufacture.—IV. By J. Swinburne 187
The Physical Properties of Manganese Steel ... 188
The Telephone in the West of England ... 189
The Union Storage Cell ... 190
Death of Sir Francis Bolton ... 190
Correspondence ... 190
The Value of Telegraphic Communication in Time of War.. 191
RETROSPECT OF THE PAST YEAR (Illustrated.) ... 192
Literature ... 201
A New Telephone Transmitter. (Illustrated.) ... 202
Improvement in the Bernstein System. (Illustrated.) ... 202
A New Theory on the Sense of Hearing ... 204
Companies' Share List ... 204
Traffic Receipts ... 204

1886.

Twelve months have passed, and yet it seems but yesterday we were discussing the then position of electrical science. The time has come round again when it is customary in these pages to pass under review the work of the past year. Can the most staunch believer in the progress of electrical science or its applications look upon 1886 as presenting any phenomenal acquisition to the annals of electrical progress? We, who have to watch closely the daily work in every department of pure and applied electricity, are fain to give precedence to the results which have arisen out of the reading of Mr. Kapp's paper, at the end of 1885, before the Institution of Civil Engineers. Dr. J. Hopkinson, on the reading of this paper, suggested certain methods of measurement as applied to dynamos, and, with his brother, Dr. E. Hopkinson, has, during 1886, if we may so speak, perfected the suggestion. We look upon the work of the Brothers Hopkinson and of Mr. Kapp in the direction of the fortelling the characteristics of a dynamo as the natural outcome of the previous paper. There is no doubt these men have done more to make the "specification of dynamos" an exact art than all other investigators besides. Progress in other directions has been decided though moderate, and is found principally in the perfection of details.

In our estimation the time has come when the initial stage —the rule of thumb stage—may be said to have passed away, and future comparisons should be made with the practice which holds at the beginning of 1887, and not with the practice that has gone before. It is suggested in some quarters that the Gramme ring armature will in the future give place to the Siemens drum type of armature. We have not now to discuss the comparative advantages of one type of armature over another, but will say that, leaving this out of question, the general type of dynamo has been obtained. Given the type of steam engine to be employed, a pretty exact specification is soon forthcoming when a purchaser requires an engine, and so it will in the future be with dynamos, fairly exact specifications being forthcoming when the work to be done is known; in other words, dynamos will in future be built from detailed specification. We do not wish to be misunderstood, and to be held to say that further progress is impossible. On the contrary, we believe that perfection will never be reached, and improvement will be more or less continuous. Already, in that fact, we hear rumours of suggestions and investigations that may revolutionise the construction of dynamos. Undoubtedly, every part of the machine will receive closer and closer attention, and although we may be supposed to be the staunchest supporters of modern theories as regards electricity and magnetism, *we are thoroughly convinced that the correct theory has not yet been promulgated.* Critically examined, there is no single theory advanced to account for the phenomena but is exceedingly cumbersome and fails at various points. Believers in a "mode of motion," in an "entity," in action in a conductor, in action entirely outside the conductor, who speak learnedly of strains, of stresses, of vortices, &c., must all feel at times that there is something yet they do not understand, and which, if they could only grasp, would greatly simplify matters. The nineteenth century will leave something for the twentieth century to do; and if we could but know ourselves as our descendants a thousand years hence will know us, we should probably be a little less troubled about orthodoxy and heterodoxy in matters scientific.

One important feature, from a business point of view, of the past year is in the increased manufacturing competition. The protection of the Gramme patent having expired, many firms concluded that they could make dynamos as well as older establishments. This was expected, and we are not sure that it is an unmixed evil. At any rate we are sure that in these days, when money is less easily made than it was in the times when "booms" reigned supreme, purchasers will consider not only first cost, but also cost of maintainence, and will not for long be tempted to patronise a maker whose machines are cheaper in the beginning, but infinitely dearer in the end. We must continue to warn our readers against being led astray by the difference of a few pounds in price lists; an extra hundred weight of coal per day because of lower efficiency, or more lubricants because of a badly balanced machine, soon counterbalances the initial saving. The older firms, however, are being taught that they will not have matters their own way, for the younger ones, by tact and energy, are obtaining a footing in places where one would not expect to see them.

Our introduction has hitherto spoken almost entirely of dynamos and dynamo construction, but the applications of electricity are by no means included in this one subject. It would be better perhaps to divide the whole subject under various headings, such as—1. Telephony. 2. Land telegraphs. 3. Cable work. 4. Electro-chemical and metallurgical industries. 5. Electric lighting industry.

I.—Telephony.

From the scientific point of view 1886 has little or no interest, but 1887 promises better things. A good deal of quiet work has been done, some of which was indicated by Mr. Preece at the late meeting of the British Association. Other

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information will, we understand, be forthcoming at one of the meetings of the Society of Telegraph-Engineers during this session. We shall content ourselves, then, with giving the commercial position of telephony so far as we can ascertain it. The largest company withholds all information; no doubt, because it thinks we are in the wrong as to our policy on the question of overhead wires. Well, the shareholders even of the United Telephone Company may wish one day they had listened to us, and sent those men adrift who persisted in the suicidal policy of overhead wires. Another storm of snow and wind about March, when the repairs are just completed, would be almost sufficient for our purpose, and compel another system to be adopted. How subscribers like having to pay in advance and not getting their money's worth is more than we shall attempt to decide. In London, at any rate, grumbling is a privilege that may well be indulged in at the present time. The energy thrown into the work by the various companies outside the metropolis is altogether a different quantity, and it is mainly from them that progress will come. The papers referred to above will be contributed by officers of the Post Office Telegraph Department and of the National Telephone Company respectively.

The NATIONAL TELEPHONE COMPANY is progressing steadily, as will be seen by a comparison of the following figures with those given in our annual article last year :—

Town.	No. of Subscribers' Lines. Exchange.	Private.	Trunk.	Totals.	Exchange Tariff.
Glasgow ... ... / Hamilton ... ... / Coatbridge ... ... / Dumbarton	1202	252	126	1454	£15
Kilmarnock	22	2	8	24	10
Ayr	15	8	6	23	10
Troon	6	—	2	6	10
Ardrossan	5	—	1	5	10
Irvine	7	—	6	7	10
Greenock and Port Glasgow	127	16	—	143	10
Paisley & Johnson..	62	8	—	70	10
Edinburgh & Leith.	363	71	—	434	15
Galashiels	Not opened.				10
Kirkcaldy	40	2	—	42	10
Stirling ... ... / Bridge of Allan ... / Alloa & Tillicoultry	39	5	3	44	10
Dunfermline	Not opened.				10
Dundee and Forfar.	634	42	36	676	10
Perth	133	—	—	133	10
Arbroath	9	1	—	10	10
Aberdeen	482	31	—	513	10
Inverness..	74	5	—	79	10
Belfast	419	101	—	520	15
Whitehaven	56	2	20	58	10
Workington	29	2	11	31	10
Maryport	3	1	5	4	10
Carlisle	43	4	—	47	10
Bradford	545	48	46	593	15
Leeds	461	77	29	538	15
Huddersfield	81	53	12	134	15
Dewsbury	123	25	17	148	15
Halifax	55	20	8	75	10
Wakefield	17	18	3	35	15
Sheffield...	24	3	—	27	10
Scarborough	26	5	—	31	12
Nottingham	308	64	8	372	15
Birmingham	469	84	3	553	15
Wolverhampton ...	48	30	5	78	10
Wednesbury	38	47	4	85	10
Brierley Hill	2	10	—	12	10
Kidderminster ...	37	1	—	38	10
Hanley	34	10	—	44	12
Stoke	11	—	—	11	12
Burslem	15	—	—	15	12
Longton	16	9	—	25	12
Tunstall	12	1	—	13	12
Derby	—	7	—	7	—
Totals	6092	1065	359	7157	

In Hanley, Stoke, Burslem, Longton, and Tunstall £12 subscription gives right to speak to any subscriber in the five towns.

The connections between Glasgow and Falkirk, Falkirk and Stirling, Falkirk and Grangemouth, Boness and Linlithgow and Edinburgh, Stirling and Bridge-of-Allan, Alloa and Tillicoultry are either completed or will be so during the next few weeks. Also between Glasgow and Helensburgh.

Conversations may be held from any exchange in Yorkshire to any town connected to the Trunk line system of the Lancashire and Cheshire Telephonic Exchange Company.

One hundred and forty-two call offices from which the public can speak have been established throughout the system.

Other important Trunk line connections are in course of construction, and several contemplated lines will be built on sufficient support being obtained.

Conversation may be held between any of the towns on the list which are "bracketed."

Carrickfergus, Whiteabbey, Newtownards, Holywood, Comber, Dunmurry, Lisburn, and Hydepark are connected to Belfast.

Hanley, Stoke, Burslem, Longton, and Tunstall are connected.

Statement of Trunk Lines.

Glasgow	*and*	Edinburgh and Leith.
,, ...	,,	Greenock and Port Glasgow.
,, ...	,,	Paisley and Johnstone.
,, ...	,,	Clydebank, Bowling, and Dumbarton.
,, ...	,,	Hamilton, Motherwell, and Wishaw.
,, ...	,,	Coatbridge and Airdrie.
,, ...	,,	Kilmarnock, Ayr, Troon, Ardrossan and Irvine.
Dundee	,,	Forfar.
,, ...	,,	Perth.
,, ...	,,	Arbroath.
Whitehaven ...	,,	Cleator and Cleator Moor.
,, ...	,,	Frizington, Harrington, and Workington.
Workington ...	,,	Maryport.
Leeds	,,	Bradford.
,, ...	,,	Huddersfield.
,, ...	,,	Dewsbury.
Bradford... ...	,,	Shipley, Keighley, and Skipton.
,, ...	,,	Stanningly, Pudsey, and Rawdon.
,, ...	,,	Dewsbury.
,, ...	,,	Huddersfield.
,, ...	,,	Halifax.
Huddersfield ...	,,	Dewsbury.
,, ...	,,	Halifax and Brighouse.
,, ...	,,	Holmfirth, Penistone, and Sheffield.
Halifax	,,	Sowerby Bridge, Hebden Bridge, and Todmorden.
Dewsbury ...	,,	Ossett and Wakefield.
,, ...	,,	Batley, Morley, and Cleckheaton.
Nottingham ...	,,	Loughborough and Long Eaton.
,, ...	,,	Basford and Ilkeston.
Birmingham ...	,,	Bilston, Dudley, and Wolverhampton.
,, ...	,,	Wednesbury and Walsall.
Wolverhampton	,,	Wednesbury and Walsall.

THE LANCASHIRE AND CHESHIRE TELEPHONIC COMPANY is a very go-ahead undertaking, as will be seen from the following statistics :—This company has about 7,000 miles of wire working, of which about 2,500 miles are trunk lines for intercommunication between towns. The Yorkshire section of the National Telephone Company's district has recently been placed in connection with this Lancashire and Cheshire system; and, by arrangement between the two companies, it is expected that the National Company's Pottery district will also be placed in communication at an early date. Further, the Northern Telephone Company's Newcastle and Sunderland district is expected before very long to be linked-up to the National Company's Yorkshire system, and thence to the Lancashire district. The rates shown are the "business" charges and for distances within a mile of the company's "centre" in the respective towns. After the first mile the additional distance is charged at the rate of £7 per mile in all the towns. Besides the "business" scale, there is a "domestic" one, by which the subscribers to the Manchester or Liverpool city systems (£20) can have their residences joined up at £12. per annum. Subscribers in the £12 towns pay proportionally. Then there is a "multiplex" system, recently introduced,

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whereby several persons may join at the use of one wire. This system, so far, is only in operation in Manchester and Liverpool, where the £20 subscription (ordinary) becomes £12 on the "multiplex;" but other towns will shortly have this new system introduced, and at proportionate rates. The popularity of the trunk wires and public call offices may be judged from the fact that in less than two years the company has reached an income, from these sources alone, of £6,300 a year. The "exchange" and private line income, including orders in hand not completed, is about £79,000. Quite 50 per cent. of the subscribers make regular use of the trunk wires, and the average daily "calls" reach 2,750 for trunk lines, as compared with 22,000 purely local. All the statistics herein are as at 24th December, 1886.

Town.	No. of Subscribers' Lines. Exchange.	Private.	Total.	No. of Public Call Offices.	Exchange Tariff.
Manchester and Sub-District.					
Manchester and Salford ... (a)	1211	423	1634	25	20
Altrincham and Bowdon ... (b)	—	—	—	—	12
Ashton-under-Lyne (a)	15	6	21	2	12
Bolton ... ... (a)	66	75	141	2	12
Bury ... ... (a)	11	4	15	1	12
Heywood... ... (a)	7	1	8	1	12
Leigh ... ... (b)	1	—	1	—	12
Littleborough... (a)	6	1	7	1	12
Macclesfield ... (b)	—	—	—	—	12
Middleton ... (a)	—	—	—	1	12
Oldham ... ... (a)	37	37	74	4	12
Radcliffe ... ... (a)	1	—	1	1	12
Ramsbotton ... (b)	2	—	2	—	12
Rochdale... ... (a)	9	13	22	1	12
Stockport ... (a)	14	5	13	4	12
Todmorden ... (a)	5	—	5	1	12
Warrington ... (a)	28	7	35	2	12
Liverpool and Sub-District.					
Liverpool and Birkenhead ... (a)	1,406	531	1,927	27	20
Chester	17	6	23	—	12
Huyton ... ... (a)	—	—	—	1	12
Ormskirk ... (a)	3	—	3	2	12
St. Helens ... (a)	17	16	33	3	12
Southport ... (a)	44	6	50	4	12
Widnes ... ... (a)	18	4	22	3	20
Wigan ... ... (a)	37	14	51	1	12
North Lancashire District.					
Blackburn ... (a)	220	34	254	5	12
Accrington ... (a)	33	17	50	1	12
Barrow-in-Furness (c)	29	21	50	—	15
Blackpool ... (a)	9	6	15	5	12
Burnley ... ... (a)	81	23	104	3	12
Chorley ... ... (a)	7	1	8	1	12
Dalton ... ... (c)	—	—	—	—	—
Darwen ... ... (a)	26	3	29	1	12
Fleetwood ... (a)	3	—	3	1	12
Lancaster	36	19	55	—	12
Preston ... ... (a)	250	24	274	5	12
Ulverstone ... (c)	1	1	2	—	15
Windermere	—	2	2	—	12
North Wales District.				No Public Call-offices opened in Wales, as these towns are not yet joined up to the Trunk-Wire System.	It is expected that the Trunk-Wire System will gradually be extended to Wales, and these towns will then be canvassed fully, and a rate fixed.
Wrexham	3	—	3		
Bangor	5	1	6		
Brymbo	—	—	—		
Carnarvon	3	—	3		
Denbigh...	—	3	3		
Flint	3	—	3		
Holyhead	3	2	5		
Llandudno	—	1	1		
Newtown	4	—	4		
Rhosllanerchrugog .	—	—	—		
Rhyl	—	2	2		
Ruabon	—	—	—		
Ruthin	—	1	1		
Welshpool	3	—	3		
Totals	3,674	1,300	4,974	—	109

The Lancashire and Cheshire towns marked thus (a) are in trunk-wire connection with each other, and also in connection with the following Yorkshire towns:—Batley, Bingley, Bradford, Brighouse, Cleckheaton, Dewsbury, Halifax, Hebden Bridge, Holmfirth, Huddersfield, Keighley, Leeds, Morley, Ossett, Penistone, Pudsey, Rawdon, Sheffield, Shipley, Skipton, Sowerby Bridge, Stanningley, Wakefield.

(b). Altrincham and Bowdon, Leigh and Tyldesley, Macclesfield and Ramsbottom not yet opened, but expected to be at an early date.

(c). Barrow, Dalton, and Ulverstone have a "group" system of trunk-wires connecting these three towns only.

The New Telephone Company.—This company, it may be said, has hardly got into harness as yet, but during the year it has, amongst other installations, supplied the Bessbrook Spinning Company, at Bessbrook Island, with ten instruments. Considerable difficulty was experienced there in consequence of the induction from the electric railway, alongside which the telephone lines were run. The installation, however, was successfully accomplished, and some credit is taken for this in that the Bell telephone had been previously tried and found wanting. At Broadmoor Asylum fifteen sets of instruments have been installed by Messrs. Paterson and Cooper, under the supervision of one of the company's staff. Messrs. Wernham and Waters, of Croydon, have been supplied with thirteen sets for the public offices in Jersey. At Poole, Messrs. Bailey and Sons' installation has continued to work well through a line of five miles in length, from Poole to Bournemouth. Instruments have been put up at Whiteley's, Westbourne-grove, and at Messrs. Huntley and Palmer's, at Reading.

In Lancashire and in Yorkshire the local agents have put up many private installations, and numerous applications have been made for the establishment of exchanges. At the present time the company is actively canvassing in Chelsea, where it is proposed shortly to open an exchange; and no doubt when we come to chronicle the work of 1887, the progress of the company will have been found to have taken place as rapidly as expected.

The South of England Telephone Company has exchanges in the below-mentioned towns. It may be recollected that Brighton is in telephone connection with London:—

Town.	No. of Subscribers' Lines. Exchange.	Private.	Trunk.	Totals.	Exchange Tariffs.
Brighton...	274	65	14	339	£12
Eastbourne	48	17	—	65	10
Hastings...	76	16	—	92	10

The Northern District Telephone Company, with head-quarters at Sunderland, has the following position:—

Towns.	No. of Subscribers' Lines. Exchange.	Private.	Totals.	Ex. Tariff. Per Ann.
Sunderland	215	31	246	£14
Darlington	11	1	12	12
Durham	6	4	10	12
East & West Hartlepool.	35	3	38	12
Middlesbro'...............	56	13	69	12
Newcastle-on-Tyne	54	22	76	12
North Shields	5	4	9	12
South Shields, Tyne Dock	22	6	28	12
Stockton.....................	26	2	28	12
Bishop Auckland	—	1	1	—
Alnwick	—	1	1	—

Subscribers in Newcastle can speak free to Sunderland and *vice versâ*; subscribers in Middlesbro' can speak free to Stockton and *vice versâ*.

It is intended shortly to join this Company's system with that of the National Telephone Company and Lancashire and Cheshire Telephone Company.

Sunderland, Darlington, Durham, East and West Hartlepool, Middlesbro', Newcastle-on-Tyne, North Shields, South Shields, Tyne Dock, and Stockton, are connected together by trunk wires.

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The Telephone Exchange Company at Sheffield is in the position as below:—

Town.	No. of Subscribers' Lines. Exchange.	Private.	Total.	No. of Call Offices.	Exchange Tariffs.
Sheffield...	343	54	397	12	£10

The Western Counties and South Wales Telephone Company is referred to in our other columns, in an article which has been for some time in type, but which has hitherto been crowded out by press of other matter.

V.—Electric Lighting.

Our attention this year has been directed to the getting together illustrations of the types of dynamos now made rather than towards the recording the actual installation work done during the year. However, we have before us a fairly exhaustive account of such work, and may be permitted to refer to some of it before coming to the dynamos. Before this, again, must come a brief reference to legal matters. *The* legal topics of the year have been, so far as electricians are concerned, "incandescent lamp patents" and "compound winding patents." The case of "Edison-Swan *v.* Woodhouse-Rawson" went in the first part to the Edison-Swan combination—the result of the second part is not yet known. Meanwhile, the Brush Company guaranteed to indemnify the users of their Victoria lamp, in the production of which new processes have been introduced; and Mr. Bernstein, as will be seen from a report given in another column, has modified his original methods because of the trial. The question of compound winding is still *sub judice*, though several of the manufacturers have, in schoolboy parlance, "caved in," becoming licensees of the Brush Company.

A correspondent, Mr. S. F. Walker, writes at considerable length about the present condition of legal and patent questions. We are fain to let Mr. Walker speak for himself, pointing out that while such an eminent scientific man as Mr. J. F. Moulton is almost always engaged as one of the counsel in these technical cases, there is not much danger of judge or jury going scientifically astray. Although, John Bull like, if we had an opinion we should probably try and stick to it, if Mr. Moulton disagreed with us after careful investigation, we should be rather inclined to imagine we "might be mistaken." And again, we must admit our judges to be somewhat akin to other eminent and well educated men, therefore it is but just to suppose they are fairly well acquainted with many matters scientific. Perhaps one would not suspect the Prime Minister of England to know much about scientific matters, yet if some of the professed practical and scientific men were pitted against him they might find to their astonishment that he knew more than they. Lastly, it must never be forgotten that so-called "expert witnesses" appear on both sides, and their statements are as wide as the poles asunder. The "expert witness" is our *bête noir*; but we have always before us the constructive difficulty. We cannot easily suggest a better system, though we rail against the present system. Those who think with Mr. Walker—and we have reason to know their number is legion—will perhaps tackle the difficulty, and if any one succeeds in solving it, the space occupied with this lament will not be wasted. Mr. Walker says—

"You may perhaps allow me a small space to point out what in my opinion is likely to interfere more than anything else with the progress of electrical engineering. I refer to the, as it appears to me, very unjust administration of our Patent Laws. How long, Sir, are our law courts, when engaged in the trial of a scientific patent case, to be the laughing stock of the scientific world? Is it not absurd on the face of it, that where hundreds of thousands of pounds, perhaps, are depending upon a just judgment between rival claimants, that their claims should be argued by a brace or a quartette of advocates who have only the most superficial knowledge of the subject, before a judge who knows absolutely nothing of it? I remember, in my very young days, when the results of examinations were important factors in my future, hearing it stated that the perfect idea of an examination was, that the examiner was supposed to know nothing, and the examined were to teach him. I believe, Sir, that if students coming up for examination were perfect in their subject, this would be by no means a bad test. As matters stand the universal practice is, so far as I am aware, to appoint as examiner the most capable man obtainable in that special subject. That is to say, where the question is whether John Jones shall pass, or he or John Brown shall have the prize, every care is taken that the judge thoroughly understands every detail of the subject. Where, however, the question is one affecting very large sums of money, often the welfare and the comfort of very large numbers of people, and where one would think even greater precautions should be taken, the *examiner*, to our disgrace be it said, is perhaps the only person connected with the case who is profoundly ignorant of the subject. At any rate he must, except in special cases, know least of anybody in court. Would it not be simpler to entrust the decision of such cases to a trio of schoolboys? With the English schoolboys love of fairplay, and with their young brains unbefogged with the contents of those proverbially dull, musty folios, that are said to contain common sense—if you can only find it—we should at least be sure that no unfair advantage would be taken by either advocate. I have no doubt it will be said that the judge decides on the evidence before him, and that his legal mind is trained to balance the opposing opinions, &c. The assumption here is that a judge trying a patent action is in the same position as when he is trying, say a property action, a will case, or a criminal action. A little thought will, I think, convince everyone that this is not so. Trying a will case or a property case, he has either to decide on the balance of evidence as to actual facts, or as to the meaning or proper application of certain words in a document; and here his whole legal training comes in to aid him. He is like an old gladiator watching the exercises of younger ones. The heirs of male entail of the tenth earl, or the eleventh duke, and all the musty legal phraseology that so bewilders us, is as familiar to him as volts and amperes are to us. And in a criminal action a similar reasoning holds good His training and experience tell him intuitively how to hold the balance, so that there shall be no undue weight on either side; and, moreover, he is familiar, from his pre-judicial practice, with the manner in which prosecutions and defences are got up, and can rightly appraise the value of a witness or the argument of an advocate. But turn to the case of patent actions. A judge may have to decide one day between two rival gas engine makers, when perhaps he has not an idea what a gas engine is; next day between two makers of ordnance; and the next one a sweeping electrical patent, such as our American cousins claim and their English owners endeavour to enforce by every means that money will furnish. Now, Sir, I will ask any reasonable man to say if it is humanly possible that any man, however gifted—and I may here mention that our judges may be taken to be among the most gifted men of their day—could acquire merely from what a witness can say in court, and the opposing counsel cannot make him unsay, sufficient knowledge of each of the above subjects to enable him to give a just judgment upon the exceedingly knotty points that

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always arise? How many of the readers of *The Electrician* thoroughly understand, for instance, the working of a gas engine, or of an automatic expansion steam valve? To show the absurdity of the matter more clearly, what engineer is there who would venture to give a judgment upon some knotty legal question? What a thorough contempt the gentlemen of the long robe would have for any one of us who tried. Can they understand what a thorough contempt we have for them when they make the childish blunders that are inevitable to a man arguing upon a subject he knows nothing about? I have no doubt it will be said, further, that it is the experts who decide the case; or, rather, the judge, from what he has gleaned from their evidence. I confess that I have been struck with the great ability exhibited in the judgments pronounced by some of our judges, and I have wondered how on earth they managed it. The secret will be found, I think, in this, that the judgment is usually based upon the evidence of some witness who has secured the ear of the judge, and whom the opposing counsel has been unable to move. It is this witness, then, who really decides the case; but if this is so, is it just that he should be both judge and advocate too. For advocate he undoubtedly is. He is paid to win the case for his clients; and, whether consciously or not, he will view every part of it through the medium of the big fee he has received. Everyone knows that there are at least two ways of looking at every one of the points that arise in scientific patent cases; and the able man who is thoroughly master of his subject, and will take one view and adhere to it, wins the case for his client. But, someone doubtless objects, you forget the opposite counsel and that fearful cross-examination. Well, let us examine this. In the first place, it would certainly conduce very much to the interests of justice if counsel would get it out of their heads that an opposing witness is, as a rule, committing deliberate perjury, or prevaricating. He looks at things from the point of view of his client's interests. But the way to get over that is for counsel to go inside, to examine from inside. But as it is not easy for them to acquire sufficient knowledge to do this, they too often resort to the practice of trying to worry the witness into saying something he does not mean. Now as to the cross-examination, let us see what it means. In many cases it means bullying. But suppose it does not. You have a learned man, in the full dignity of wig and silk, and perhaps in the receipt of a revenue that would be welcome to many a landowner. And facing him stands a man whose name, perhaps, is renowned throughout the world, and who will live in men's minds hundreds of years after the advocate lies forgotten in his grave. What is the advocate now, in comparison with this giant? He is a boy of ten, and he is asking those questions that children of his age are wont to, and that are puzzling to ordinary mortals, and with a view of puzzling—*the Master*. Does it not sound absurd? Cannot we imagine some smart youngster at one of our public schools trying to puzzle the College Don who has come down to examine his class, and the amusement of the latter? I trust, Sir, that an abler pen than mine will take this matter up. The result of our present system is, I believe, in the opinion of the great majority of men who are competent to judge, that grave injustice has been done in very many cases in the matter of scientific patents."

Now to business. Many firms have been fairly busy with installation work during the year. As examples, we may refer to the Brush Company, which has lighted the ss. "Tamar," belonging to the Royal Mail Steam Packet Company, with Victoria lamps, worked by a Victoria Brush compound dynamo driven by a patent "Brush" engine and "Raworth" friction gear; the ss. "City of London," the "City of Aberdeen," and the "Ban Righ," belonging to the Aberdeen Steam Navigation Company, fitted throughout with Victoria lamps supplied by Victoria dynamos, driven by "Brush" engines and friction gear; the extension of the lighting on board the ss. "Orient," where sixty lights have been added, with a Victoria dynamo, driven by Brush engine and friction gear. The corporation have also during the past year fitted up numerous torpedo boats for the Spanish, Dutch, and other Governments with incandescent lamps and search light apparatus, the dynamos being driven by direct acting engines, and they are now engaged in fitting up other vessels in different parts of the world. With regard to the Exhibition contracts secured during the past year, it may be mentioned that the corporation had the largest share of the lighting at the Indian and Colonial Exhibition, where, in addition to supplying upwards of 170 Brush arc lamps of 2,000 candle-power each, they also supplied a large number of Victoria incandescent lamps for the high mast lighting and the dynamos for the fountain illuminations. At the Edinburgh Exhibition a large number of Brush arc lamps were supplied, and the Old Edinburgh section was lighted with their incandescent lamps, with marked success. At the Liverpool Exhibition the corporation supplied through the local contractors, Messrs. Holmes and Vaudrey, upwards of 350 arc lamps, of 2,000 candle power, with Victoria and Brush dynamos, and this exhibition was lighted almost entirely with apparatus manufactured by the Brush Co. Among the public and other buildings lighted during the past year may be mentioned the following:—Drapers' Hall; this installation consists of twin Otto gas engines, running from flywheel on to a Victoria dynamo supplying current for incandescent lamps and arc lamps, storage cells being also employed, arranged two in parallel. The work of running leads for this installation has been executed throughout in accordance with the rules laid down by the Phœnix Fire Office. In connection with the installation at the National Agricultural Hall, now commonly called "Olympia," the corporation obtained the contract for the supply and fixing of all the wires and lamps required for the buildings. The arc lamps are of the well-known Brush pattern, specially fitted and arranged to work from the same wires that supply the incandescent lamps. Fifty-four arc lamps are suspended, in nine groups of six each, from the lofty roof of the grand hall. They also supplied as many as ninety arc lamps of 2,000 candle-power, with necessary dynamos, engines, &c., at very short notice, for temporary lighting during the building operations. This temporary lighting has proved a very great success and convenience, since it enabled the completion of the building to be effected in time, and the plant used for this lighting has since been continued as accessory to the permanent lighting. The Junior United Service Club, Charles-street, S.W., is lighted with Victoria lamps, worked by a Victoria dynamo and storage batteries. The Glasgow Western Baths are fitted with a Victoria dynamo, arc lamps, and incandescent lamps; the dynamo also supplies current for lamps installed in Hillhead Chapel, situated close by. The Uleaborg Hotel, Finland, is fitted with Victoria-Brush dynamos—driven by a Brush engine—Brush-Sellon arc lamps, and Victoria lamps. Among the mill and factory installations may be mentioned the following:—Messrs. Ritchie and Co., Stroud; Messrs. Fox Brothers and Co., Wellington; A. Laverton, Esq., Westbury Mills, Wilts; the Bowness Manure Works; and the following works in the north of France:—G. and H. Barrois, near Lille; Ravinet Frères, Dunkerque; La Société des Moulins de Prouvy; Messrs. A. Lorthios and Co., Tourcoing; M. Avot Vallée, Blandecques. Among the private

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residences lighted by the corporation during the past year may be noted:—R. Taylor, Esq., Huntsmoor Park, West Drayton; H. Hucks Gibbs, Esq,, Aldenham House, Herts; Abel Buckley, Esq., Rycroft Hall, Ashton-under-Lyne.

A company that has shown great energy during the year, and has been very successful in securing orders, is the Gülcher Company, who favour us with a list of nearly eighty installations completed during the year. In addition to these installations, which have been erected complete, the company has supplied a large number of dynamos for lighting and depositing purposes, as well as a large number of arc lamps. The Gülcher Company, it will be recollected, carried out the lighting at Birmingham during the meeting of the British Association, and, so far as we could see, there could be no fault found with the work. Their installation at the Crystal Palace has been extended by twenty arc lamps in the palace and twenty-two in the grounds. At Edinburgh the company had an installation of sixty-four arcs and seventy incandescent lamps. Altogether the work of the company involved the use of over 500 arc lamps, and nearly 5,000 incandescent lamps, as well as the necessary dynamos. Although several of the installations were for exhibitions, and therefore temporary, the larger number are permanent.

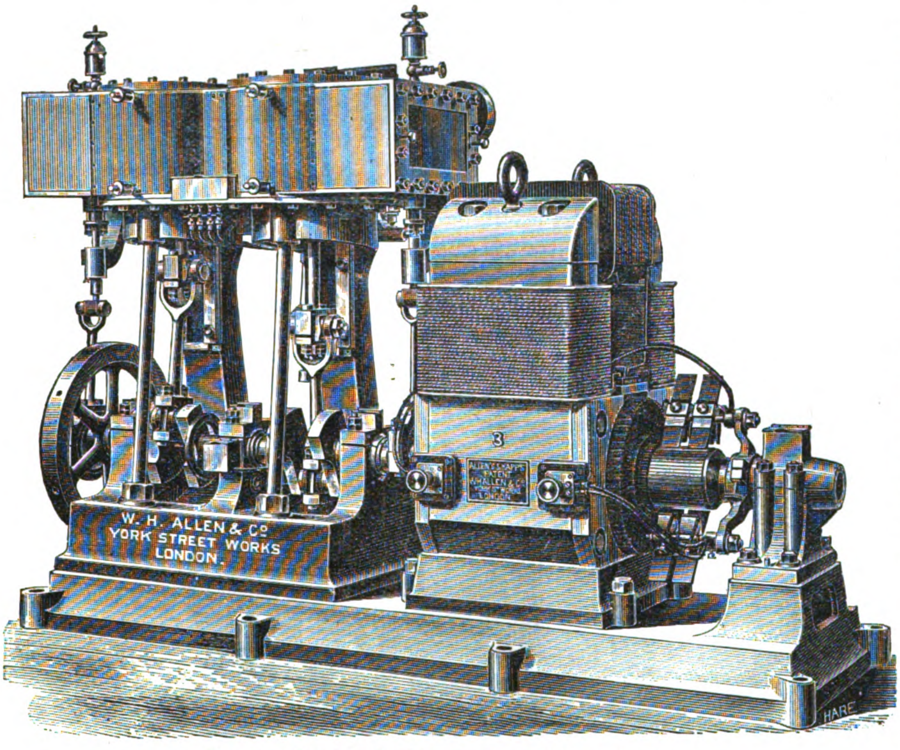

Fig. 1.—Combined Allen Engine and Kapp Dynamo.

Among the country firms Messrs. Walker and Olliver have done a good deal of work in connection with mines. The installation of signalling apparatus is steadily progressing. Electric light installations have been carried out at the New Tredegar Colliery, belonging to the Powell Duffryn Company, where 3 arc and 43 incandescent lamps are used. This is the third colliery fitted up for the company by Messrs. Walker. The Rainston Collieries, belonging to the Marquis of Londonderry, have also been fitted by this firm with 1 arc and 80 incandescent lamps. The Seams Colliery at Gateshead has been lighted both on the surface and underground. The Harris Navigation Colliery has recently been lighted on the surface with 83 incandescent lamps. It may seem that the light progresses slowly in colliery work, but it is satisfactory to find that such companies as the Powell Duffryn are lighting colliery after colliery, showing most conclusively that the system finds favour in their eyes. This firm has adopted the Gramme form of machine, the old type being of course greatly modified which they manufacture.

Sufficient has been said to show that progress is steady in almost all directions. Central station lighting in England is not very prominent, but the year 1887 will probably see this system in actual work at Kensington Gore. Mr. Crompton long ago made us acquainted with the work in contemplation, and we hope soon to be able to commence an exhaustive illustrated description of the scheme. Modifications are, however, necessarily frequent in work of this kind till near completion, hence we prefer to see the dynamos revolving rather than on paper.

We have previously said that the rule of thumb stage of dynamo construction has passed away, and we have endeavoured to bring together into this article illustrations of various dynamos as constructed by different makers at the present time. Readers will look in vain for any reference to some noted manufacturers, such as Messrs. Siemens; but the time is far from opportune for this firm, their machines being in a state of transition. The new designs intended to replace the old are not quite ready, and it is preferable to wait for the new machines than to illustrate the old and well-known type. In the construction of dynamos, so far as commercial and electrical efficiencies are concerned, makers run each other closely. There does not seem to be much chance of improvement in these directions when we hear of 90, 94, 95, and even 96 per cent. efficiency. There seems to be no valid reason why from 90 to 95 per cent. electrical efficiency should not be the rule rather than the exception. The direction in which improvement may be expected is in output for weight within certain limits. There is little doubt but that English makers take the foremost place both as regards efficiency and output for weight, and we trust they will long continue to hold this position.

Messrs. W. H. Allen and Co., of York-street Works, Lambeth, have manufactured during 1886 a considerable number of Kapp dynamos, both for belt driving and for direct driving. A large number of combined dynamos and twin engines, illustrated in the annexed engraving (Fig. 2), have been made to the order of the Admiralty, whilst a few smaller sets have been made to the order of private ship builders for use with search lights on torpedo boats. Another type of combined engine and dynamo, of which four sets were made during the year for ship lighting, is shown in Fig. 1. In this arrangement the engines are twin-compound, and may be worked together or independently, while in the case of a double break-down either engine may work either dynamo. A number of belt-driven dynamos have been supplied to customers in England, Norway, Germany, Denmark, and Italy. In all these machines the magnets are of the simple horseshoe type, placed vertically, with the poles above, and the yoke in the bed-plate.

The Brush Company—which we should call the "Anglo-American Brush Electric Light Corporation," but which we prefer to give, as they do Acts of Parliament, a short title, one

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that is sensible and usable—has broadly two types of dynamos, each of the main types, however, being subdivided into minor types. Firstly, they have the "Brush" type; and, secondly, the "Victoria" type. The Brush dynamos are now all fitted with the new wrought-iron armature, and hold a leading, if not the leading, place among machines of high E.M.F. for actuating arc lamps or groups of incandescent lamps in series. It may be noticed here, as favourable to the early work of Mr. Brush, that his machine, in the development of the industry, has undergone fewer alterations in design than any other of the early machines. The Victoria dynamo has taken a high place among the modifications of the original Schuckert. During the past year improvements have been made in this machine, increasing its efficiency and reducing its first cost, by increasing the quantity of soft iron in the machine and decreasing the quantity of copper. Victoria machines have been used during 1886 for the purposes of operating Brush arc lamps in parallel, for incandescent lighting, for operating search lights, and the transmission of power. When used as motors they give satisfactory results. Fig. 3 shows the Brush type of machine, and the following figures, relating to a Brush 27-unit machine—*i.e.* a machine to give 27,000 watts—will be interesting, and more so because the increased output is due to the modification in the quantities of iron and copper just referred to, the output of the older type being 20,000 watts, and the E.M.F. at terminals 2,000 volts. The E.M.F. at the terminals of the machine reaches the high figure of 2,700 volts, and the dynamo is intended to be used for 55 arc lamps in series of 2,000 nominal candle-power each. These lamps require 50 volts × 10 amperes, or 500 watts each, the machine giving 10 amperes current at the above voltage when making 850 revolutions per minute.

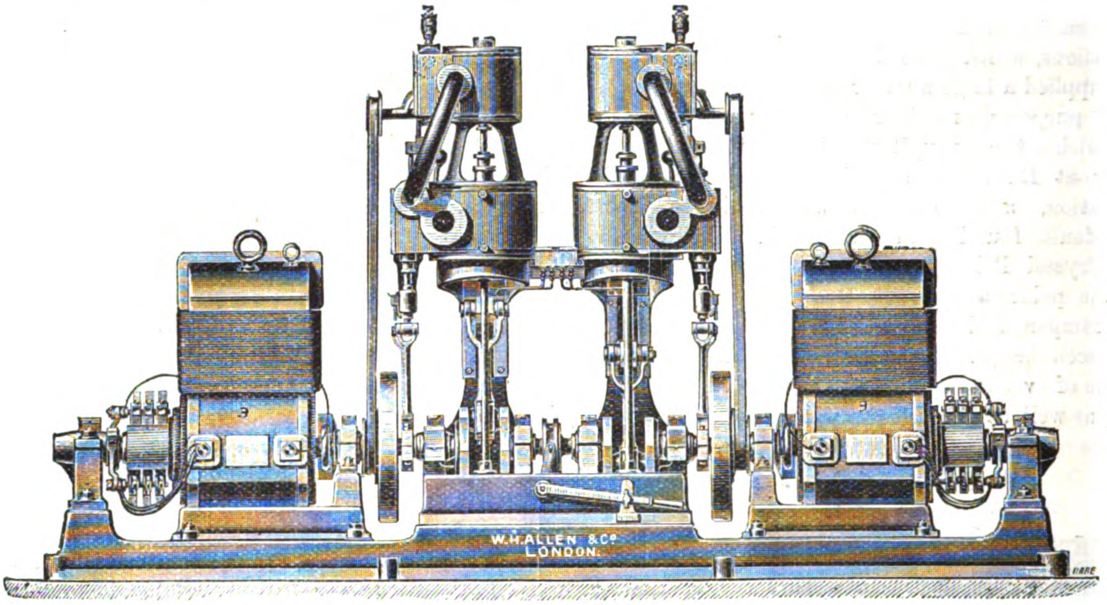

Fig. 2.—Allen's Twin Tandem Compound Engine and Kapp Dynamo.

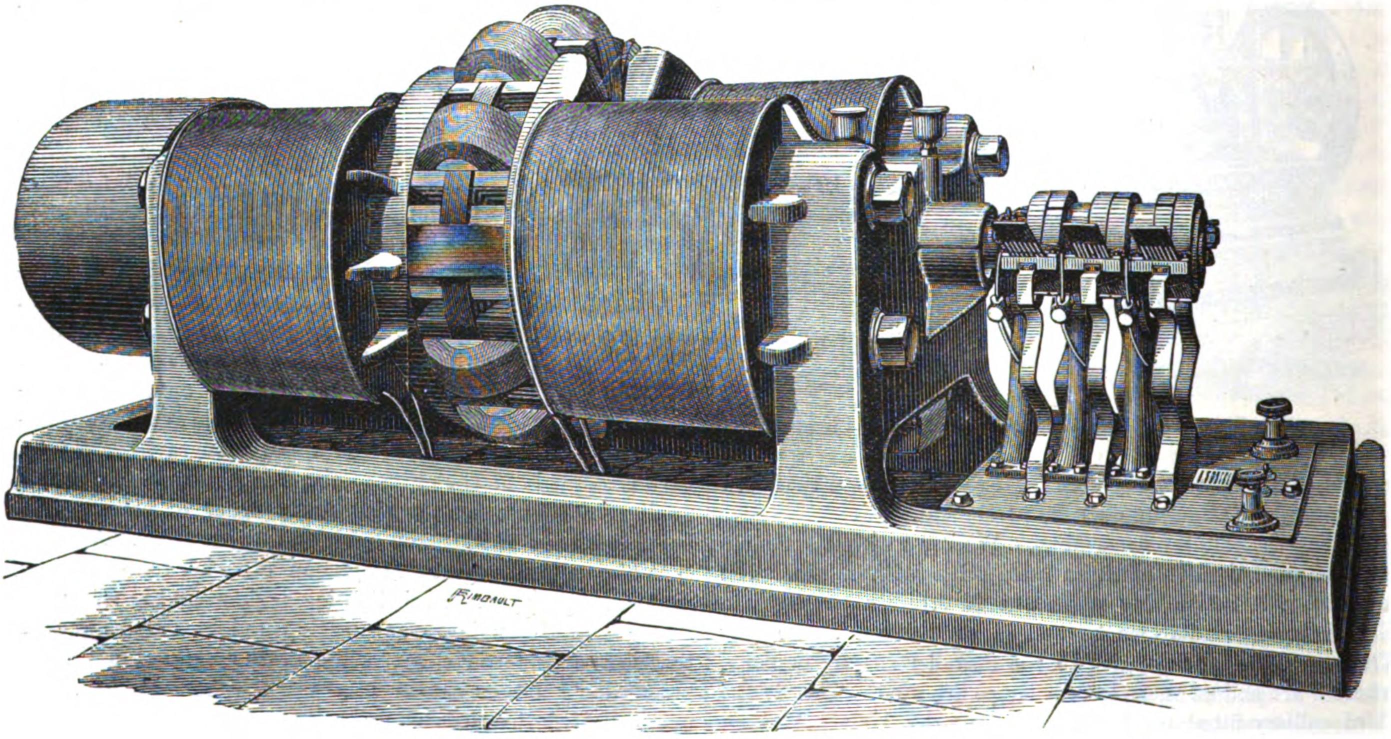

Fig. 3.—The Brush Arc Dynamo.

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The total weight of this machine is 2 tons 13 cwt. Fig. 4 illustrates a Victoria dynamo. The following figures relate to a 12-unit machine, generally known as a D_2 machine, which at 800 revolutions gives a current of 185 amperes, with an E.M.F. at terminals of 65 volts. The weight of the machine is 17cwt. 19lb. It is self-regulating for constant E.M.F. The

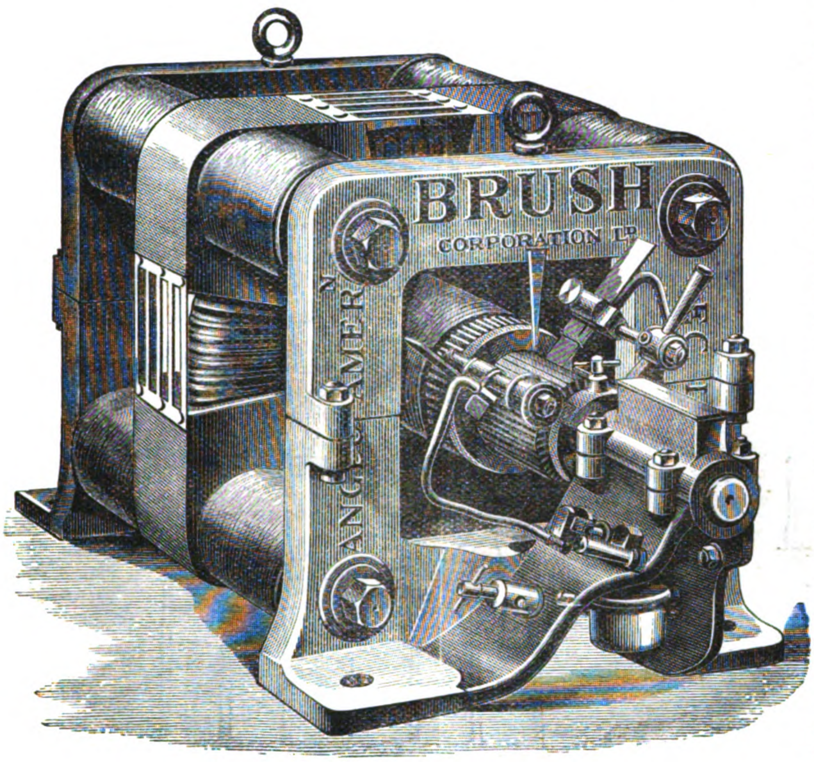

FIG. 4.—The Victoria Dynamo.

field-magnet coils have a resistance of ·002 ohm, the shunt coils of 15 ohms. The current density in the field-magnet

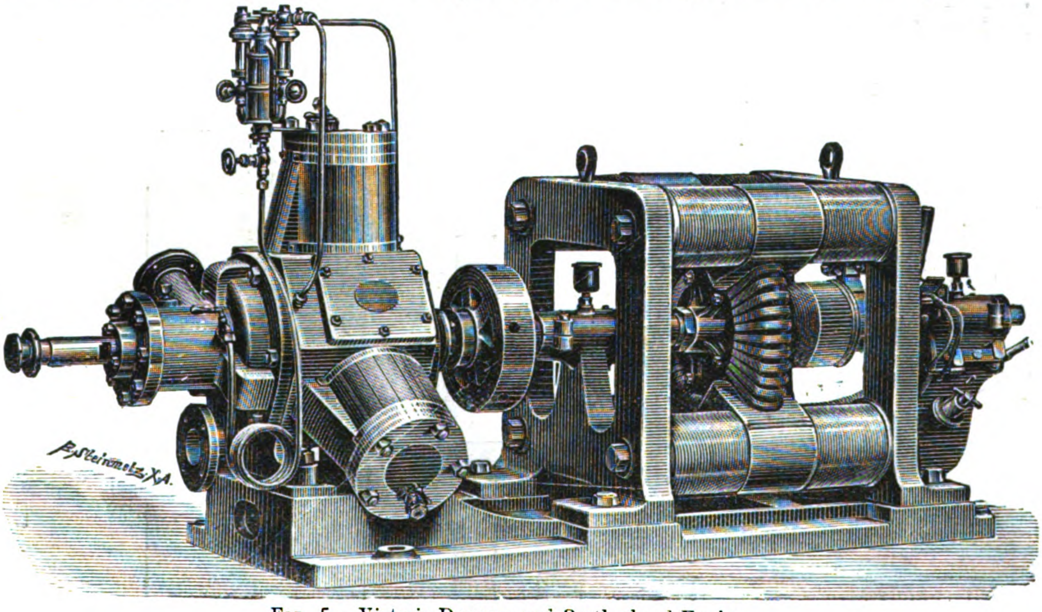

FIG. 5.—Victoria Dynamo and Brotherhood Engine.

coils is 830 amperes per square inch, and in the armature coils 2,000 amperes per square inch. Fig. 5 shows a Victoria dynamo, driven direct by a Brotherhood engine.

Messrs. R. E. CROMPTON & Co., of Mansion House-buildings, E.C., and Arc Works, Chelmsford, have also been busy during the past year in the construction of dynamos, and Fig. 6 illustrates a very large Crompton machine of a type not hitherto described. This machine has its field-magnets separately excited, and is shown in the figure coupled direct to a Willans three-cylinder engine, driving at 400 revolutions per minute. It has an output of 72 units, or 97 estimated horse-power, and absorbs 106·5 brake horse-power, showing a commercial efficiency of 91·8 per cent. The electrical efficiency is 94·5 per cent., and the total efficiency of con version is 97 per cent. At the above-mentioned speed the machine gives 600 volts at the terminals with a current of 120 amperes. The total weight of copper used is 1,400lbs., showing an output of 51·5 watts per lb. of copper. The armature is of the Gramme type, having the following dimensions:—Axial length 34in., diameter 15·5in., radial depth 3·125in. The copper on the armature weighs 287lbs., and has a total length of 915 yards, wound in 440 turns. The sectional area of the conductor is ·026in., showing a resistance between the brushes of ·23ω. The current density allowed is 2,300 amperes per square inch. The strength of the field in the armature is 17 lines per square inch, the total cross sectional area of the iron being 221 square inches, and the internal E.M.F. 631 volts. The total weight of iron used in this part of the machine is 5 cwt. The external watts per lb. of armature copper amount to 250, and the terminal volts per yard to 0·65. The clearance allowed for the armature is 0·76in., the peripheral speed is low, being only 1,620ft. per minute. The commutator has 110 parts. The bearings are 10in. in length, and are made of cast iron with white metal run in. The field-magnets are built of the best scrap iron and weigh 5 tons; and each of the four magnets measures 3ft. by 2ft. by 7½in.

The four coils are wound with 2,200 yards of wire of diameter ·237in. (sectional area ·044in.), and their resistance as connected amounts to 32ω. There are 304 turns, giving, with the full current of 36 amperes in each coil, 11,000 ampere turns, or 44,000 for the whole field.

The total watts lost in these coils amounts to 1,870, the current density allowed being 820 amperes per square inch. The over-all dimensions are, length 5ft. 9in., height 7ft. 10in., width 4ft. 0in.

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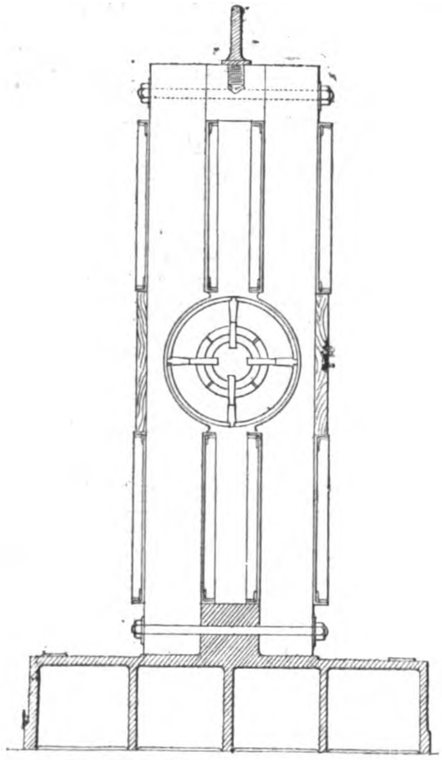
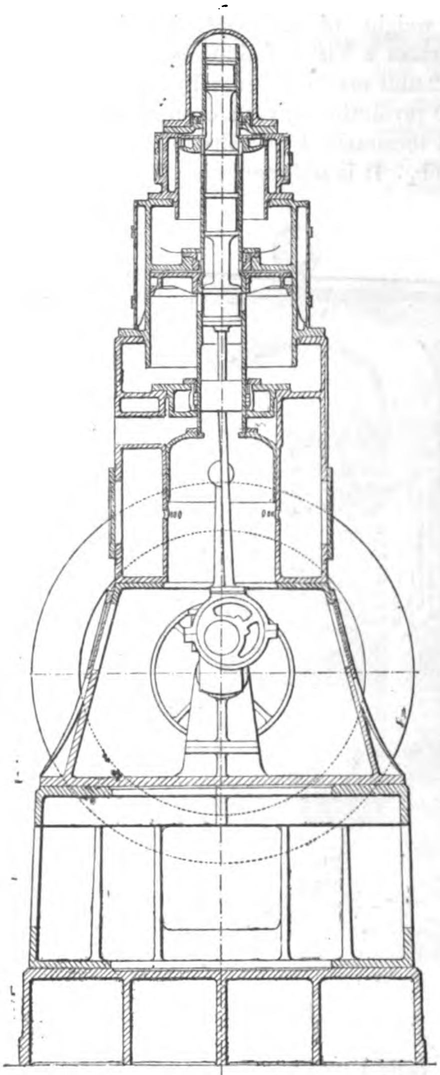


Cross Section on A B.

FIG. 7.



Cross Section on C.D.

FIG. 8.

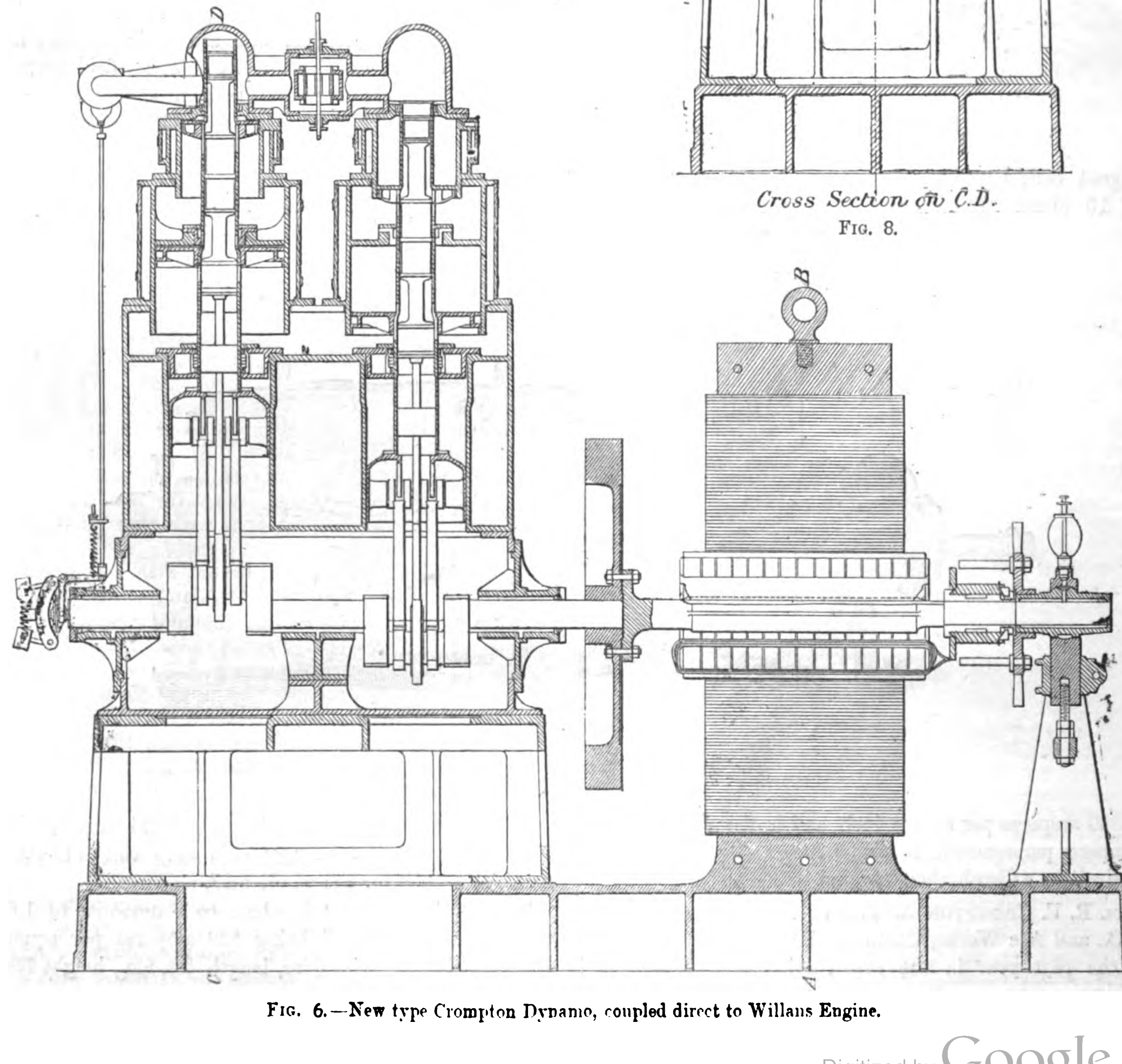
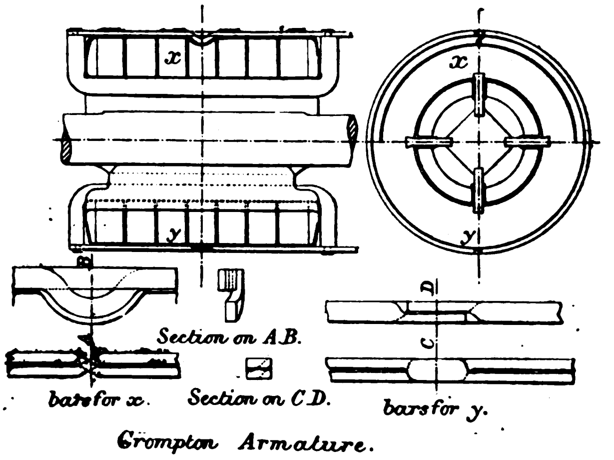


FIG. 6.—New type Crompton Dynamo, coupled direct to Willans Engine.

Fig. 7 is a cross section of figure on the line A B; Fig. 8 is a section of the engine on the line C D; Fig. 9 represents

Fig. 9.



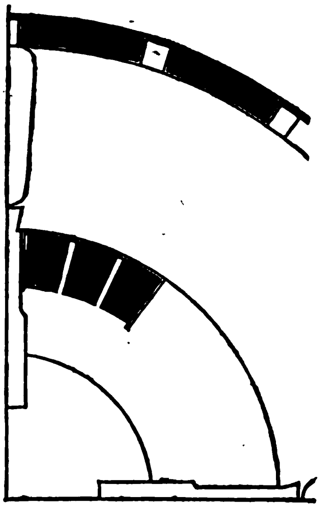


Fig. 10.—Section of Crompton Armature.

the Crompton new armature, and Fig. 10 a section of the same.

(To be continued.)

ELECTRICAL COMPANIES FORMED DURING THE YEAR 1886.

The following table gives the companies formed during the year to carry on electrical work :—

(1) *Represents Limited Liability of Shareholders.*

Name of Company.	Capital Authorised.	Capital Offered.	Amount of Share.	Deposit on Application and Allotment.	Total Deposit.
			£ s.	£ s.	£
Electric Locomotive and Power (1)	60,000	60,000	5 0	2 0	24,000
Internationl Cable (1)	1,000,000	600,000	10 0	1 0	60,000
Railway Electric Lighting (1)	130,000	130,000	5 0	2 10	65,000
Regent Portable Electric Lamp and Lighting (1)......	85,000	57,000	5 0	2 0	23,000
United River Plate Telephone (1)........................	500,000	250,000	5 0	2 10	125,000
West African Telegraph (1)...	400,000	250,000	10 0	3 0	75,000

LITERATURE.

A Text Book on the Steam Engine: Specially arranged for the use of Science and Art, City and Guilds of London Institute, and other Engineering Students. By Andrew Jamieson, Assoc. M.I.C.E., M.S.T.E. (London: Charles Griffin, 1886.)

We have often been asked by students to give them the name of a good text book on the steam engine, and have as often been unable to mention any one book; it has always been necessary to mention several, as equally indispensable, no single book containing all that a student requires. Prof. Jamieson's new book has very materially limited the number of books which must be mentioned in reply to such a question, and in many cases his will answer every requirement. It is difficult to say wherein lies the secret of Mr. Jamieson's success, for it is good in method, in matter, and in the selective judgment that he has displayed in dealing with practical subjects for the theoretical explanations throughout the book. For once we have a practical theoretical book.

The book consists of thirty lectures, and the author's method is first to give a description of the early steam engines and of those down to the time of Watt's latest improvement, so that the learner first gets a good notion of what a steam engine was. He then leads through thermometry and heat measurements to the use of heat for evaporating steam, keeping the student's attention close to the questions of relation between units of heat and the effects of their application. From evaporation he passes to expansion and condensation, the behaviour of steam in a steam engine cylinder, and in general the thermodynamics of the steam engine. Then he measures the power of the steam engine in various ways, and compares work actually done with the theoretical mechanical equivalent of the work represented by the heat passed to the engine or in the steam used. He then describes modern engines of various kinds, showing the difference between engines of to-day and of the time when little was known by engine makers of the direct relation between heat and mechanical effect. The various details of usual engines are described, and plenty of sections of real engines are given, though they are not all well printed. Three chapters are given on boilers of different kinds, and every chapter throughout the book is followed by a set of questions, all of which are of a practical order—that is to say they are not mere puzzles or arithmetic conundrums, but they are such as will cause the student to refer back to the chapter preceding, and by seeing the application learn to appreciate the information given him.

In dealing with questions which are often confusing to the learner, such as those relating to latent heat, to isothermal and adiabatic expansion of steam, Prof. Jamieson is very clear and concise, and it is a merit of his book that, whether descriptive or explanatory, his style is everywhere lucid without wordiness. His drawings and diagrams are well chosen, although the printer has not done justice to all. In brief his book is the best written book published for the purpose on the subject. There is nothing new in the book—the new things we expect from the men in practice—but it has the highest merits as a compilation. There are a few points to which attention may be directed as not quite in agreement with the praise we have felt compelled to bestow upon Mr. Jamieson's book.

In dealing with the indicator diagrams from a triple cylinder engine, and in reducing them to the same scale, he takes the weight of steam used per stroke in the high-pressure cylinder, and reduces this to volume of cylinder both high and low plus clearance per 1lb. weight of steam. He thus gets quantities that represent the relative lengths, *i.e.*, the volumes of the several diagrams. This is clear enough to the initiated and to the student who is helped by a lecturer, but it is not quite so clear for a student who is working by himself, as it is, at least in the first instance, necessary to know that the lengths of the respective diagrams will be proportionate to the relative volumes of the cylinders. The author remarks concerning the rise of an indicator curve above the theoretic saturation curve that this "can only be accounted for by the action of the steam jacket in re-evaporating moisture in the cylinder, or by the steam being superheated by the excessive wire drawing."

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With reference to this, we may remind the author that these rises in the curves are found in diagrams from engines with unjacketed cylinders, that the rise in pressure due to jacketing, or the cessation of reduction in pressure, need not be sudden, as is usually shown by the curve; thirdly, that the cessation of reduction seems to take place more in cylinders with a somewhat early cut off and high pressure than with later cut off and moderate pressure; and, fourthly, that the cessation seems to be due to re-evaporation of steam condensed in the cylinder in the early part of the stroke partly by the heat given to the cylinder walls and piston, and partly its own heat, which comes into play with the lowering of pressure by the movement of the piston during expansion. As to the superheating by wire drawing, although the author is able to refer to the authority of some writers on this point, it is questionable whether any such superheating occurs; but if it does, it may help to explain the fact that some engines with a throttle valve are as economical as others with an automatically variable cut-off. In dealing with the effects of the inertia of the moving parts of engines the author quotes from Mr. Imray's paper before the Institution of Civil Engineers, but he might with advantage have gone to Mr. Arthur Rigg's book on the steam engine.

In his treatment of boilers of various kinds the author has not entered into the "how much," which is necessary for every student. He is not shown on what method to proceed to estimate the power of a boiler, the necessary disposition or estimation of the heating surface or the grate surface. In dealing with Cornish and Lancashire and Galloway boilers, he does not enter into the design and proportion of the flues for these boilers, and, further, he does not deal with the proportions of chimneys for these.

Having pointed out these omissions, we must conclude by mentioning that one of the most valuable features of Prof. Jamieson's book is that he not only freely mentions the sources of his information wherever it is special, but he gives the name, date, and page of his authority. These references must be of great assistance to every student who wishes to follow the subjects thoroughly, and add very much to the value of the book.

A NEW TELEPHONE TRANSMITTER.

In the accompanying engraving Fig. 1 represents a liquid transmitter, which is so wired that in its normal state the current circulates around the induction coil D with its full strength. The reason for this is that the vibrator is then nearer the screw A than the screw C. The vibrator is actuated by the diaphragm of the mouthpiece E, and its lower end enters between the points of the screws A C, the conducting liquid contained in the non-conducting vessel G. It is evident that the strength of the current passing around the induction coil will be governed by the variations of the distances of the vibrator between the screws, and which are due to the action of the diaphragm in the mouthpiece. One of the many ways of wiring the instrument is clearly shown in the engraving. Another is to connect the wire leading from the positive pole of the battery where the negative wire is shown connected, and connect the negative wire with the wire of the screw A.

FIG. I.

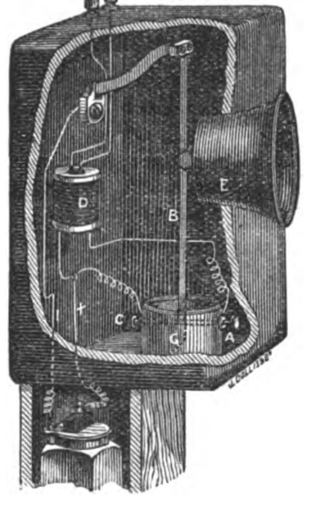

FIG. 2.

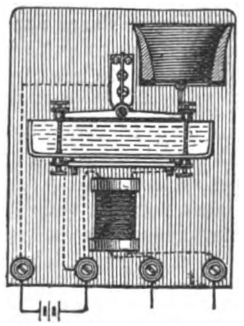

Fig. 2 shows another construction of the transmitter, in which the vibrator consists of a centrally pivoted lever, which is actuated by the diaphragm in the manner illustrated. Each end of the lever carries a screw that projects downward into the liquid, so as to face a screw passing through the bottom of the vessel. The distance between each pair of screws will thus be varied by the movement of the diaphragm, and the strength of the current passing through the coil will be regulated accordingly.

This invention has been patented by Mr. F. G. Sargent, of Graniteville, Mass.

IMPROVEMENTS IN THE BERNSTEIN SYSTEM.

On Monday, January 3rd, Mr. Bernstein invited the members of the Society of Telegraph-Engineers to a practical demonstration of recent improvements in his system of lighting. The remarks of Mr. Bernstein are given below, with illustrations of his new variable resistance plug (a most ingenious piece of apparatus) and his new switch. Most of our readers will recognise the great simplicity now attained in this system in comparison with that described in Mr. Bernstein's paper read before the Society of Telegraph-Engineers last year. Mr. Bernstein said:—

In the spring of last year I had the pleasure of reading a paper before the Society of Telegraph-Engineers and Electricians, in which I described a system of electric lighting by means of low resistance lamps. Since that time I have devoted myself exclusively to perfecting the details of this system, and to-day I am in a position to show you the system in practical operation. As I could not invite all the members of the society to come here, I limited the invitation to you, as members of the council, and I beg to express my thanks for your kind response to my invitation by your appearance here.

Allow me to enumerate in a few words the different parts of the system. We require a dynamo of high E.M.F. and producing a constant current. Conductors, which are made to carry a current of 10 amperes, and of high E.M.F. lamps for the same current, switches to turn lamps in and out, and an arrangement which prevents the interruption of the circuit in case a lamp should break—these are the essential features.

Now, as to the dynamo. Having no facilities in London at my disposal for building dynamos, I accepted an offer of Messrs. Elwell-Parker. I intended to have three sizes of dynamos built, viz., of 300 volts, 600 volts, and 1,000 volts. One of 300 volts and another of 600 volts have been finished, and of the last kind one is now in course of construction. The dynamos have Gramme armatures and commutators, and have shunt-wound magnets. The results hitherto obtained as regards constant current are very encouraging; but as they are due to the experiments of Mr. Parker I think it right to leave the publication to him.

I have given special preference to dynamos of the Gramme type over those of Brush or Thomson-Houston, because the two last machines do not produce a perfectly constant current, but rather a waving current, and are not nearly as economical in the conversion of mechanical power into electric energy as the perfected Gramme dynamo is. I have further come to the conclusion that for very long circuits it is better to connect two dynamos of 1,000 volts each in series instead of using a dynamo of 2,000 volts, and this for the following reasons:—In a system of series lighting perfection of insulation should be a primary condition. The most dangerous part of the series system rests at the dynamo, where the difference of potential reaches its maximum value. By reducing this difference of potential to one half, we reduce the danger to one quarter. 1,000 volts on each dynamo present no difficulties, and the insulation in the dynamo itself and from the ground can be made quite perfect.

None of the difficulties which are attached to the use of several dynamos in parallel exist if the connection is made in series. But there is another advantage in the use of two dynamos of 1,000 volts of the Gramme type in series, and this is the fact, that two of these dynamos are cheaper than any 2,000-volt dynamo at present in

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the market. This, at first sight, appears singular, especially as we have been frequently told that it would be advantageous to build large sized dynamos, but is nevertheless a fact.

In regard to the conductors I shall have very little to say. I may be allowed to mention here that the rules published by the Phœnix Fire Office respecting conductors carrying a high tension current are exceedingly vague. They merely say that these conductors ought to be at least from six to twelve inches apart. Now, as a matter of fact, the wires leading to every one of these lamps can in this case never have more than ten volts difference of potential between them, and they are far safer by being laid quite close together than twisted wires would be in a parallel circuit, in which there is everywhere a difference of potential of 100 volts. It is quite apparent that the distance between two wires ought to be regulated by the difference of potential between them. Another point is the laying of wires inside of wooden casings. A conductor of the kind which I am using here can be treated somewhat like a gas pipe, and is in factories often less liable to be injured when exposed to view than when concealed. I was pleased to notice that the same idea seems to be gaining ground in America.

Turning now to the lamp, you will find that it has received no material alteration in appearance since the time I exhibited it to the Society of Telegraph-Engineers. As a matter of fact, the old method of making the carbon had to be abandoned on account of the decision which the Edison-Swan Company obtained in regard to the Sawyer patent, and a new method for producing a dense and hard carbon of uniform section had to be devised. The lamp has well fulfilled all my expectations. The lamps which are laid here for your inspection have been used for more than 1,000 hours, and do not show any signs of blackening. They do not now absorb any more power in proportion to the light for the production of the light than they did in the beginning. This is a very important feature if you consider that, according to the tests made by the Franklin Institute, lamps of high resistance will require almost twice as much power for production of the same amount of light as they gave at first after they had been in use for 1,000 hours.

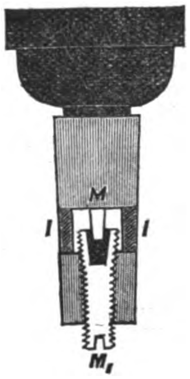

Fig. 1.—The Bernstein Variable Resistance Plug.

I now beg to call your attention to the most important and most difficult part of the series system, viz., the way of preventing interruption of the circuit in case a lamp should break. For this purpose the application of a very complictaed mechanism has always been necessary, and this mechanism was the most objectionable feature in a system of series lighting. I have been able to overcome this difficulty in the following manner:—I place two small pieces of metal in a shunt round each lamp, and separate these pieces of metal by a thin film of a metallic compound, for instance, oxide of mercury mixed with carbon powder. If the lamp is in proper condition, an exceedingly small current will pass through this mixture, which has a resistance of about 500 ohms; but if a lamp gives out, its resistance increases very rapidly and a larger current will pass through the shunt. The larger current now produces such local heat in the film of oxide of mercury that an instantaneous reduction of the oxide takes place, and a certain amount of metallic mercury is formed. A free passage of low resistance for the whole current is thereby produced, and an interruption of the circuit is impossible. This apparatus, which is made in the form of a small cone (Fig. 1), is arranged to fit into the switch, as I shall describe later on. In Fig 1, MM_1 shows the metallic connections, II. the insulating medium. The black part is the oxide of mercury and carbon dust. The screw M is used to obtain the necessary resistance by increasing or decreasing the pressure. I shall now demonstrate the action of these contacts by first connecting one with a single lamp, in which case they have no effect whatever on the light of the lamp, and afterwards connect the same contact with a large number of lamps, or disconnect the wires from the lamps entirely, and you will find that the contact acts in the way I have described. [Experiment performed.]

These contacts play a similar part in the series system which the fusible wires do in the parallel system, but the latter break the circuit in case the current becomes too strong, and the former make a circuit under the same condition. I think the contact is an interesting example of the replacement of a complicated mechanical apparatus by a very simple chemical action. It follows from the action of the contact that it has to be replaced after it has once acted, but as there is nothing used up except the metallic compound, the renewal of the contact is done at a mere nominal expense.

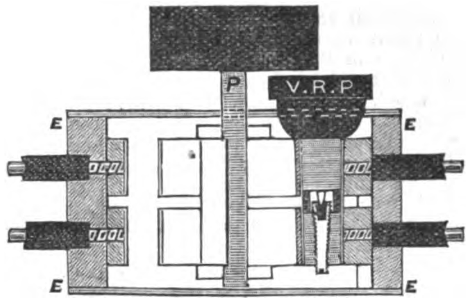

Fig. 2.—Bernstein Double-Pole Short-Circuiting Switch.

I shall now lastly describe the switch (Figs. 2 and 3) which I have designed for this system. It may be briefly specified as a double-pole short-circuiting switch. All the working parts of the switch are fastened to the inside of a small ebonite cylinder, closed at each end, so that contact from the outside with any part conveying a current is impossible. There are four segments fastened on the inside of this cylinder, two of which receive the line wires, and the two others the lamp wires. A central pin, P, which is insulated from all the working parts, carries an ebonite handle outside the box, and two metal pieces inside, which in a certain position of the handle connect the line wires with the lamp wires. If the handle makes one quarter turn these two metal pieces rest on insulation, but before this can take place another piece of metal connects the two line wires, thereby producing a short circuit of the line inside the switch. Two metal bosses, provided with a taper hole, are connected with the segment which carries the lamp wires. The contact plug fits into this hole, and if put in forms a shunt of high resistance to the lamp. The arrangement of the handle and the contact plug is made in such a manner that the current must be short-circuited before the contact can be removed; and it is further arranged that the contact must be put in its place in order to obtain a light in the lamp. This last has been done in order to prevent people from using a lamp without protection of the circuit by means of the contact.

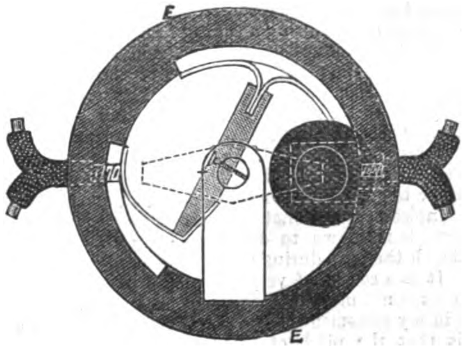

Fig. 3.—Plan of Switch.

Allow me now to add a few words in regard to the practical use of the system. A small experimental plant has been in operation in the alkali works of Messrs. Brunner, Mond and Co., at Northwich, the light having been kept constantly running from four o'clock in the afternoon till eight o'clock next morning, since the middle of October last year. Not the slightest hitch has occurred since starting the plant, and there has been no cessation of the lighting during the specified time, even for one minute, although the plant is superintended by an engineer who never had anything to do with electric light before. I think this speaks well for the security and simplicity of the system. Another plant was started in our own factory about the same time, the light being kept running every day from morning to night. A third plant has lately been put in operation for lighting the cooperage at the above-mentioned alkali works, and a fourth plant will be started next week for lighting the saw mills of Messrs. G. Smith and Co., on these premises. I hope that these demonstrations, and the facts laid before you, may have proved that my labours in this direction have not been in vain.

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A NEW THEORY ON THE SENSE OF HEARING.

At the Birmingham Meeting of the British Association a lecture was delivered by Dr. William Rutherford, M.D., F.R.S., on "The Sense of Hearing," from which we take the following highly interesting passage :—

Some five years ago it struck me that the case of the telephone may throw light on these difficulties regarding the sense of hearing. In the telephone there is a thin plate of iron placed near the end of a permanent steel magnet. A bobbin of thin copper wire is coiled round the end of the magnet nearest the plate, and is connected with a bobbin of wire around the magnet of a second telephone in every respect similar to the first. When sound waves fall on the plate of the transmitting telephone it vibrates. The vibrations of the iron near the magnet affect the magnetism, and so induce in the wire currents of electricity whose frequency and amplitude correspond to those of the vibrations of the iron plate induced by the sound. The currents travel to the receiving telephone and induce oscillations of its magnetism, which in turn cause its iron plate to vibrate and produce sounds similar to those communicated to the first telephone. These is no analysis of the sound waves. The transmitting telephone takes up simple or complex vibrations The harmonies of an orchestra may fall upon it, and it does not fail to convert the complex sound vibrations into electrical vibrations, and these again into the complex sound of the orchestra in the receiving telephone. It is, indeed, one of the most wonderful inventions of recent times. Can it throw light on the sense of hearing?

The theory which I have to propose may be termed the Telephone Theory of the Sense of Hearing. The theory is that the cochlea does not act on the principle of sympathetic vibration, but that the hairs of all its auditory cells vibrate to every tone, just as the drum of the ear does; that there is no analysis of complex vibrations in the cochlea or elsewhere in the peripheral mechanism of the ear; that the hair cells transform sound vibrations into nerve vibrations similar in frequency and amplitude to the sound vibrations; that simple and complex vibrations of nerve molecules arrive in the sensory cells of the brain, and there produce, not sound again, of course, but the sensations of sound, the nature of which depends not upon the stimulation of different sensory cells, but on the frequency, amplitude, and form of the vibrations coming into the cells, probably through all the fibres of the auditory nerve. On such a theory the physical cause of harmony and discord is carried into the brain, and the mathematical principles of acoustics find an entrance into the obscure region of consciousness. Now, if nerve energy were only electricity, that theory would probably be accepted at once. But nerve motion is very sluggish when compared with electricity.

I have kept this theory back for five years, because I felt I had no evidence of the possibility of sending a rapid succession of vibrations along a nerve. It cost me a good deal of thought and experimental observation to find the evidence I required. If we give to a motor nerve of a frog or rabbit ten instantaneous shocks of induced electricity in a second, ten impulses will pass along the nerve to the muscle, and produce ten distinct contractions in the same period. If we send forty impulses along the nerve, we get, not forty contractions of the muscle, but a single continuous contraction, because the several contractions are fused together. Now, if we listen to the muscle so stimulated, we hear a musical note having the pitch of forty vibrations per second. Each sound-vibration results from the sudden shock of chemical discharge due to the arrival of each nerve impulse in the muscular substance. If we stimulate the nerve, say, 200 times per second, by causing a tuning-fork to make and break the primary circuit of an induction machine, and so send 200 shocks per second into the nerve, the pitch of the note in the muscle exactly corresponds. It has the same pitch as the fork. I experimented in this way, and eventually found that I could send as many as 352 impulses per second along the nerve of a rabbit and get a note from the muscle of the pitch of 352 vibrations per second—that is, a note of the pitch of F in the lowest space of the treble clef. But when I tried by more rapid stimulation of the nerve to get a higher note from the muscle, I failed; there was nothing but a noise heard. That a low rumbling sound is produced by a contracting muscle is known to every physiologist. You can hear it if you firmly clench the jaws during the stillness of night, when other sounds are hushed. It is a sound of very low pitch due to vibrations certainly below 40—perhaps not more than 10 or 12 per second. There is therefore nothing new in my statement that a note may be heard in a muscle; the new point is that the pitch of the note may be increased by a more rapid stimulation of the nerve, and that as many as 352 impulses may be sent along a nerve and retain their individuality so sharply that they can produce a note in a muscle having a pitch number of 352. That fact will give support to a vibrational theory of nerve energy.

Now, am I to conclude that, because I failed to get a higher note than one of 352 vibrations from the muscle, it is not possible to send more than 352 vibrations per second along a nerve? By no means; the fibres of a muscle are very different from those of a nerve, and also very different from nerve cells. The molecules in both of them can probably vibrate far more rapidly than 352 times per second.

I have, therefore, directly proved that vibrations of the same frequency as all the lower tones of the scale, from the lower F of the treble clef downwards, can be transmitted by a nerve. A short time ago it occurred to me that the note produced by the wing of an insect furnishes a simpler proof of the possibility of transmitting a rapid series of impulses along a nerve. The wing of the humble bee produces the note F in the lowest space of the treble clef. It gives, therefore, 352 complete vibrations in a second. Every downward motion of the wing doubtless results from an impulse sent along the nerve to the muscle that lowers the wing. Therefore we may conclude that about 352 impulses per second traversed the motor nerves of the humble bee's wing during flight. In the honey bee the note of the wing is A in the treble clef—that is, two notes higher than in the humble bee, so that 460 impulses appear to pass along its motor nerves in a second. In a human motor nerve the impulses transmitted by it during voluntary effort are not more than 10 or 12 per second (Schaefer). I have, therefore, some substantial evidence in support of my theory of sound sensation. And I cannot but think that the evidence in favour of it will increase. I do not wish you to suppose that on my theory of hearing difficulties disappear. Far from it. I merely assert that the difficulties which seem insurmountable on the theory of Helmholtz are diminished by the theory which I have submitted. Should my theory of the sense of hearing find acceptance, it will lead to a reconstitution of theories regarding the other sense organs.

BUSINESS NOTE.—We understand that Mr. Henry Edmunds has become a partner in the firm of Walter T. Glover and Co., the electrical wire and cable makers of Salford, Manchester. The firm have taken new London offices, at No. 10, Hatton-garden, E.C. Mr. Edmunds will continue to reside in London.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Jan. 5.		Business Done Week Ending Jan. 5. Highest.	Lowest.
Anglo-American	35½,	36½	36	—
Do. Preferred	59,	60	60	59
Do. Deferred	13,	14	—	—
Brazilian Submarine	10⅞,	11⅛	11 1-16	10 15-16
Cuba	11,	11½	—	—
Do. Preference	18,	19	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Preference	9½,	10½	9⅞	—
Direct United States Cable	8⅞,	9⅛	8⅞	—
Eastern Telegraph	10⅜,	10⅝	10½	10 5-16
Do. 6 per Cent. Preference	13½,	14	—	—
Do. 5 per Cent. Debentures, 1899	106,	109	108½	—
Eastern Extension	10⅞,	11⅛	11⅛	10⅞
German Union	9,	9½	—	—
Globe Telegraph and Trust	5¼,	5½	5⅜	5 3-16
Do. Preference	12¼,	12½	12½	12½
Great Northern	13⅛,	13⅜	13½	13¼
Indo-European	34,	35	—	—
Reuter's	7,	7½	—	—
Submarine	190,	200	—	—
West India and Panama	¾,	1	¾	13-16
Do. 1st Preference	8½,	9	8⅞	8⅝
Western Brazilian	7½,	7¾	7 9-16	7½
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	⅞	—
Oriental	¼,	⅜	—	—
United Telephone	12½,	13	13¾	12¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	2⅞	—
Do. (fully paid)	4¼,	4¾	—	—
Swan	1½,	2	1¾	—
Maxim Weston	5-16,	7-16	—	—

MISCELLANEOUS.

Telegraph Construction	39	40	39⅞	39½
India Rubber, Gutta Percha, and Telegraph Works	24	25	24⅝	24½

TRAFFIC RECEIPTS FOR DECEMBER, 1886.

Companies.	Dec., 1886.	Dec., 1885.	Increase.	Decrease.
Cuba Submarine	3,100	2,448	652	—
Direct Spanish Telegraph	1,767	1,764	3	
Eastern Telegraph	52,823	53,179	—	356
Eastern Extension	40,539	34,785	5,754	—
Great Northern	19,600	—	—	—
West Coast of America	4,590	—	—	—

Duncan Wallet and Co.,

EXPORT PROVISION MERCHANTS,

Shippers of Wines, Spirits, Teas, Coffees, &c., in Bond.

15, BILLITER STREET, LONDON.

Special Arrangements made for supply of Telegraph Stations & Cable Steamers abroad.

Messrs. D. W. & Co. supply Provisions and Bonded Stores to the CABLE STEAMERS of several Companies, also to VARIOUS STATIONS of the EASTERN and EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANIES, and are prepared to execute orders on specially favourable terms on shortest notice.

INSULATED ELECTRICAL WIRE, Silk, Cotton, or India Rubber covered. Conductivity guaranteed. German Silver Wires for Resistance. Braided Handle Cord, Silk Cord for Electric Bells, &c.—WILLIAM RICKARD, Derby. London Agent (stock kept) EDWIN HOLLOWAY, 2, Gutter-lane E.C.

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NOTES.

Reported Illness of Edison.—A Philadelphia telegram in *The Times* states that Mr. T. A. Edison is lying seriously ill.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended January 7th amounted to £3,477.

The West Coast of America Telegraph Company.—The directors of this company have declared an interim dividend of 2s. per share.

Electric Lighting Tender Wanted.—Messrs. Foster Brothers, of 254—256, Coventry-road, Birmingham, invite tenders for the supply of plant, including engine, for lighting their premises by electricity.

The Commercial Cable Company.—This company last week completed the second year of its existence, upon which occasion each of the *employés* was presented by Mr. Mackay with one half of a month's salary.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending January 7th were £2,762, after deducting the fifth of the gross receipts payable to The London Platino Brazilian Telegraph Co.

Telephone Telegrams in Belgium.—The last return of the number of telegrams delivered by telephone in Belgium is at the rate of nearly half a million per annum. This probably implies a substantial saving in the wages of telegraph messengers in the larger towns.

"Munro and Jamieson's Pocket Book of Electrical Rules and Tables."—We have received a copy of the fourth edition of this well-known work, to which further additions have been made. The book is published by Messrs. Charles Griffin and Co., of Exeter-street, Strand.

American Electrical Patents.—The United States Patent Office has prepared a reprint of patents relating to electricity issued up to July 1, 1881. The specifications are arranged under sixty-nine sub headings, and fill sixteen quarto volumes of 2,000 pages each. The price is $454.

The Edison System in France.—A project has been set on foot for the amalgamation of the three companies which are engaged in the "exploitation" of the Edison system in France. These are the "Continental Edison Co.," the "Société Electrique," and the "Société Industrielle et Commerciale Edison."

The Direct United States Cable Company.—At the board meeting on January 7 it was resolved to pay an interim dividend of 2s. per share, free of income-tax, being at the rate of 2 per cent. per annum, for the quarter ending 31st December, 1886, such dividend to be payable on and after the 22nd inst.

The Colonial Conference.—The Colonial Conference on Postal and Telegraphic Communications will be opened in London on 1st April next. The colony of Victoria will be represented by the Hon. James Lorrimer and the Hon. Alfred Deakin. New Zealand will be represented by Sir Francis Dillon Bell.

La Société Générale des Telephones.—At the close of 1886 the French Telephone Company had reached a total of 6,890 subscribers, of which 111 were connected during the month of December. A new telephone company is about to be established in France to work micro-telephones patented by M. C. Herz.

Submarine Cables Trust.—Notice is given by this trust that the balance of ten shillings left outstanding on the coupon of October 15th, 1886, will be paid on and after the 15th inst., by Messrs. Glyn, Mills, and Co., of Lombard-street, between the hours of 10 a.m. and 2 p.m. The coupons must be left with the bankers five clear days previously to calling for payment.

Electric Railway in Austria.—In addition to the scheme for an electric railway at Buda-Pesth, which we recently described, the Austrian Minister of Commerce has granted a concession to the firm of Siemens and Halske for the construction of an electric railway from Salzburg to Lend, and thence to Wilbad-Galstein. It is intended eventually to prolong the line to Bockstein.

Temporary Lighting.—The Tradesmen's Association of Batley instructed Messrs. Goolden and Trotter, of Halifax, to illuminate the principal thoroughfares of their town on Christmas Eve and the preceding evening. The lighting was carried out with complete success by eleven arcs, on a circuit of rather more than a mile in length, and, we believe, had the desired effect of assisting a brisk Christmas business.

Cockermouth.—The Town Council of this town, at several of their recent meetings, have had under their discussion the question of asking for tenders for lighting the streets of the town by electricity by means of power derived from the River Wear. No definite conclusion has been arrived at, but the council are still open to suggestions upon the subject.—The National Telephone Company are about to extend their system to Cockermouth.

An American Suggestion for Solving the Wire Problem.—Col. Flad, President of the Board of Public Improvements of St. Louis, proposes the erection of iron towers 100ft. to 150ft. high at the street corners to carry all overhead wires. The towers are to rest upon four arched supports meeting at a height of 40ft. or 50ft. over the centre of the roadway. Arc lamps to be suspended from the centre of the arch, and all wires to range perpendicularly at various levels.

Tenders Required for Electric Lighting in Spain.—The Municipality of Lorca, a town of 50,000 inhabitants in the south of Spain, invites tenders for electric lighting under conditions favourable to the contractor. A monopoly of fifty years is guaranteed, and the town itself will pay £720 per annum for 260 20 candle-power lamps, while private lighting may be undertaken on such terms as the contractor thinks fit to offer. Further particulars may be obtained on application to the municipality.

The Lighting of Rome.—Messrs. Ganz and Co., of Buda-Pesth, write to inform us that the alternating current machines and transformers for the extensive installation which is about to be carried out by the Anglo-Roman Gas Company will be supplied by them, the transformers being of the well-known Zipernowski-Deri-Blathy type. Messrs. Ganz and Co. have carried out central lighting stations upon this principle in the following towns up to date:—Milan, Turin, Bogni di Lucca, Treviso, Lucerne, Gerona, and Montevideo.

The Society of Arts.—The last Wednesday evening lecture at the Society of Arts was delivered by Prof. Reinold, F.R.S., who gave the second of his two juvenile lectures on "Soap Bubbles." Among many other experiments of great interest and beauty was one which consisted in sending a current of electricity up or down a soap film. It was shown that a fluid current was set up in the film corresponding with the nominal direction of the electric current, so that the film became rapidly thinner near the electrode at which the current entered.

The Austrian Telephone Company.—Messrs. F. C. Stoop and Co. write us as follows:—"The Telephone Company of Austria has been more fortunate than the London company, as you will perceive by the following extract from a letter from

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the manager :—'We have had heavy snowstorms, but happily up to now no damage worth mentioning ; all that was done was to throw some trees on some of our pole lines in Bielitz, breaking about ten wooden poles, which were replaced in a day.' The company have now 1,700 subscribers to its exchanges in Austria."

A State Electrical Laboratory for France.—The French Government has decided to establish "a central laboratory of electricity," under the direction of the Minister of Posts and Telegraphs. M. de Nerville has received the appointment of director of the new institution, although nothing has yet been decided as to the exact organisation and functions of the establishment. It is, however, probable that the verification and calibration of electrical instruments will form the chief part of the work undertaken, and it is hoped that a department for special research will also be included. A commission is to be appointed to determine these matters.

The South of England Telephone Company.—We are now able to supplement the details which we gave in our last issue respecting the work of this company by the following complete list of the exchanges which they have now in operation :—

Company's Exchanges.	Lines to Exchange.	Company's Exchanges.	Lines to Exchanges.
Brighton	282	Dover	23
Hastings	77	Maidstone	16
Eastbourne	55	Northampton and Wellinboro'	89
Norwich	76	Cambridge	120
Ipswich	70	Oxford	28
Great Yarmouth	11	Reading	60
King's Lynn	18	Bedford	18
Chatham	24	Luton	37
Folkestone	28		

The Zanni Incandescent Filament.—The *Chronique Industrielle* states that the Zanni filament is made by the following process :—Ground carbon is mixed with gas tar so as to form a stiff paste, and is then placed in a metallic cylinder, having at one end a small hole, the diameter of the required filament. The material is then forced through this hole under strong pressure. The threads thus formed are cut up into suitable lengths, and raised to a white heat in a closed muffle. This leaves the filament in a porous condition. The material is then dipped in a solution of platinum chloride, or of calcic chloride, and again raised to a high temperature, when it is found to have assumed a solid structure. We believe that the lamps made by this process possess some good qualities, but it seems unlikely that the filaments will possess that homogeneous structure which is usually considered so desirable for lamp filaments.

A New Double Current Key for Cable Signalling. At the last meeting of the Société Internationale des Electriciens, M. L. Maiche exhibited a new double current key designed more particularly for use with the siphon recorder. Instead of a single set of contacts, as in the usual Morse signalling key, the new key has two sets of contacts, and is manipulated like a pair of single-needle pedals. The depression of the right hand key, however, transmits dashes, and that of the left hand dots, each followed by reverse currents as in the ordinary double contact key ; but by means of a mechanical attachment these reverse currents are sent after a definite interval, and for a definite period, which is independent of the actual period of depression. This is accomplished by causing the depression of each key to liberate an excentric, which is then driven forward by clockwork, and closes the circuit for the required interval in either direction. This would seem to be a substantial improvement in cable signalling apparatus.

Magnetic Insulation.—According to an American journal, a Boston scientist, who has spent the last 50 years of his life in searching for a substance which should be impermeable to magnetic lines of force, has been at length successful in the discovery of a metallic compound capable of playing the part of a perfect magnetic insulator. Although for our own part—and to put it bluntly—we attach not the slightest importance to this story as it comes to us at present, yet we are not aware of any valid reason for denying the possibility of the existence of such a substance as is here suggested. It is true that up to the present time we have no authentic record of the existence of any body whose magnetic permeability is perceptibly less than that of air, but nevertheless we do not think that in the present state of our knowledge the search for a magnetic insulator should be placed in the same category as the quest of the Philosopher's Stone or for the Elixir Vitæ. Apart from the many obvious uses for a material possessing this property, we have recently been shown a scheme which promises to revolutionise the face of the earth—so far as matters electrical are concerned—if only a magnetic insulator be forthcoming.

Halifax.—At the last meeting of the Halifax Town Council the Town Clerk read a communication from Mr. Hugh Watt, Chairman of the Maxim-Weston Electric Company, with respect to electric lighting in the borough. The letter pointed out that in the case of the Town Hall and other public buildings, a great saving would necessarily accrue in the non-destruction of decorations, painting, &c. If the Council were desirous of adopting the light the company would lay down a plant consisting of 1,000 lamps, each of 20 candle-power, including dynamos, cable, leads, labour, electrical sundries, steam engines, and all necessaries, for £3,000, provided the Council saw their way to purchase the plant out and out ; and he would be willing to maintain this at an annual cost of, say, £700 a year, although he thought after the first twelve months the Corporation would find it much cheaper to maintain the plant themselves. As to the question of rental, if the Council would place in the hands of the company an order for, say, a thousand lamps, these should be laid down, ¾d. per lamp per hour being charged for the minimum number of hours during which the lamps had to run during the year. The letter was referred to the Lighting Committee.

Hall's Phenomenon in Gases.—Professor Boltzmann has recently detected the existence of Hall's phenomenon in gases, the rotation of the equi-potential lines for carbon, di-oxide, hydrogen, and air being in the same direction as for gold. The experiment was made by means of a Geissler tube of rhomboidal section in which the gases were exhausted to the pressure of 2·5mm. The current from the induction coil entered and left the tube at the acute angles of the rhumboid, and two separate platinum electrodes inserted at the obtuse angles were connected with a very sensitive galvanometer. When the tube was placed in a uniform magnetic field such that the lines of force were perpendicular at the same time to the direction of the current in the tube and to the line connecting the secondary electrodes, a current was set up in the circuit of the latter, which, as already stated, was in the same direction as in Hall's experiment with gold leaf. Professor Boltzmann also took two similar Geissler tubes connected in parallel, so that the current divided itself nearly equally between them. If a magnetic field directed perpendicularly to the current were then set up in one tube, the current in this tube was observed to diminish to one-tenth of that in the other.

The Thermo-Electric Properties of Electrolytes.—In *Wiedmann's Annalen*, M. Donle gives the results of some

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experiments which he has carried out upon the above subject. The following are the conclusions at which he has arrived :—(1) The thermo-electric force of the combination of two electrolytes increases with the difference of temperature of the contacts; (2) The differences of potential increase in general less quickly than the differences of temperature; (3) The degree of concentration of the solutions has not much influence; (4) But the thermo-electric force increases in general when the concentration of one of the solutions diminishes; (5) In the combination of a sulphate and a chloride of the same metal, the sulphate forms the positive pole; the current passes, at the warm contact, from the chloride to the sulphate; (6) In general, the sense of the thermo-electric force is the same as that of the contact electromotive force; (7) The sense of the thermo-electric force between two salts of the same acid is the same as the electromotive force of contact for the corresponding metals. These observations have an important bearing upon various questions connected with the rational theory of chemical reactions, which is now being built up from the study of thermo-chemistry, as well as upon the intricate question of the seat of the electromotive force in the voltaic cell.

THE LATE SIR FRANCIS BOLTON.—Colonel Sir Francis Bolton was buried on Tuesday, the 11th inst., at the cemetery, Hastings, where his mother's remains lie interred. Amongst the mourners were his brother, Mr. M. W. Bolton; his cousin, Colonel Braham; his partner, Mr. P. A. Scratchley, M.A.; his solicitor, Mr. G. A. Gadsden, Mr. Thomas Bond, F.R.C.S., Mr. J. H. Francis, C.E., engineer to the New River Company; Mr. M. W. Morris, C.E., engineer to the Kent Water Works; Mr. W. E. B. Farnham, Mr. F. E. Lewis, Mr. J. D. A. Norris, Dr. Winter Fisher, Mr. H. Bird, and Mr. H. Richards. The Society of Telegraph-Engineers and Electricians was represented by two of its past Presidents, viz., Major-General Webber, C.B., late R.E. (who, with the late Mr. R. Sabine and Sir Francis, founded the society), and Mr. W. H. Preece, F.R.S. (who had been intimately connected with Sir Francis in connection with the electric lighting of the recent International Exhibitions at South Kensington), and Mr. F. H. Webb, the Secretary. Many other members of the council would have attended but for important engagements which prevented them going so far as Hastings. Mr. James Sivewright, C.M.G., travelled up from Greenock on Monday night in order to be present, but in consequence of the train being delayed reached London too late on Tuesday morning to enable him to catch the Hastings train. Sir Francis's staff was represented by Messrs. D. Urquhart, Mr. W. Bates, and Mr. R. Loam.

MR. QUARRIE'S SYSTEM OF GENERATING ELECTRICITY.—We have received from Mr. Quarrie a letter in which he is good enough to assure us that his knowledge of electrical matters "is not of that technical, abstruse, mystified, tissue of mathematical puzzles and their tangled solution, represented by the accepted scientific treatment of electricity." Mr. Quarrie's method is, on the contrary, sufficiently simple. It consists of "taking a few accepted facts, and applying the same." The only difficulty, as it seems to us, that can arise in the application of this method, is that of knowing just how many facts it is desirable to take account of, and how many may safely be left out of the reckoning. The possession of this system has, however, led Mr. Quarrie to the brilliant conception of seizing on any and every suitable occasion upon which something happens to be in motion, and attaching thereto in some manner—the details are not clearly explained—an apparatus which may perhaps be roughly described as a dynamo-armature. Thus there is no longer any need for "even the ghost of a special engine" in order to obtain "an abundant supply of electric light." How wonderfully simple! and how pleasing it is to be assured by Mr. Quarrie that he *knows* that in the end his results will astonish those arrogant persons who have hitherto "thought that they only knew anything of electric matters." Our readers must please note, however, that Mr. Quarrie has applied for, and has received, Her Majesty's letters patent for this system.

THE SCHOOL OF ELECTRICAL ENGINEERING, HANOVER-SQUARE, W.—After the Christmas examination for the final vellum certificate of this school, a very satisfactory report was received by the managers, Messrs. W. Lant Carpenter and L. Drugman, from the external examiner in the electrical subjects, Mr. H. R. Kempe, of the Engineer-in-Chief's Office, G.P.O. Out of 18 students who presented themselves from the class of the senior instructor, Mr. H. D. Wilkinson, the certificate was awarded to eight, whose *average* percentage of full marks was 91 per cent. in the theoretical questions, and 95 per cent. in the practical ones. No certificate is awarded for less than 70 per cent. in each case. The names and marks percentages of the successful students in electric lighting and power transmission are—A. G. Sanders, 99·3; A. E. Levin, 98·0; C. Mott, 94·7; W. L. Copp, 93·3; F. A. Harris, 92·0; W. F. Collins, 91·3; E. Payne, 81·3; in electric and submarine telegraphy and telephony, B. Brown, 87·3. The first seven students having previously passed the examination in the course of lectures on mechanical engineering receive the full certificate of the school, which, we may add, now numbers 55 pupils. A steam engine will very shortly be placed in the machine room to replace the gas engine at present in use. We are also informed that arrangements have just been completed, whereby, in addition to the course of practical instruction in the school itself, advanced students will have the opportunity of gaining actual experience by spending a portion of their time in the workshops of Messrs. Swete and Main, electrical engineers, Kensal-road, W.

"LES TELEPHONES USUELS."—We have received from MM. J. Lebèque et Cie, of Brussels and Paris, a copy of "Les Telephones Usuels," by M. Charles Mourlon. This is a work of some three hundred pages, profusely illustrated, and containing elaborate descriptions of a very large number of modifications of the original Bell Telephone, some good, some bad, the majority probably indifferent. Given a magnet of indeterminate shape, one or more helices of indefinite dimensions, and some structure which fulfils the not very onerous condition of coming within the legal definition of a diaphragm, and it is obviously possible to construct an indefinite series of instruments more or less capable of fulfilling the purposes of a telephone receiver. Observations of a similar character will apply to the transmitters, which are also extensively represented in these pages. It has been a matter for surprise to us to learn what a large number of gentlemen of French and Belgian nationality have occupied their leisure in ringing the changes on this gamut. We turned with greater interest to Chapter IV., on "Bureaux Centraux," hoping to find some detailed information on a subject on which much remains to be said. The information which is given upon this head is, so far as it goes, of a valuable character, and the illustrations are well and clearly drawn; but the information is by no means brought up to date, and several improvements of American origin are entirely omitted. The book is one which in other respects deals in a satisfactory manner with the subjects taken up, and which include batteries, insulators, lines, call-bells, and other subsidiary apparatus. But we are still of opinion that the standard treatise on telephony remains to be written.

LIGHTNING PROTECTORS FOR TELEGRAPH AND TELEPHONE CIRCUITS.—In a paper upon the above subject by M. F. Van

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Rysselberghe, which appears in the *Bulletin de la Société Belge d'Electriciens*, the author divides lightning protectors into the following classes :—(1) Fusible wire protectors. (2) Protectors based upon the discharging effects of points, and consisting usually of two opposed plates of metal studded with numerous points. (3) Protectors in which the discharge is effected in a vacuum by means of Geissler tubes. (4) Protectors in the form of condensers, consisting merely of two metallic plates separated either by an air-space or by a thin sheet of paper. M. Rysselberghe then describes a series of experiments which he has undertaken in order to determine which of these forms is the most effective. He has been led to the conclusion that the protectors classed under the third division are the most generally useful. Nevertheless, an extended experience of the fourth class, in which reliance is placed upon a simple condenser with a paper dielectric, has shown that this form is equally effective in action. More than 2,000 such protectors are in use in Belgium, and although last year was an exceptionally stormy period only two actual failures are reported. The objection to the system, however, arises from the fact that after any very energetic discharge not only is the dielectric pierced but the line is frequently put to earth. This, says M. Rysselberghe, is not a serious inconvenience when the protector is placed in a telegraph office, where matters can immediately be restored to their normal condition, but it renders the type unsuited for use with telephonic apparatus. For the latter purpose, therefore, M. Rysselberge prefers to use a Geissler tube protector with electrodes of nickel.

With all Humility.—We are sure that our readers will share with us the concern which we feel on learning that a proposal recently put forth in these columns has "made *The Electrician* ridiculous in the eyes of all France." So at least we are assured by one of our contemporaries across the Channel; and as if this were not in itself a sufficiently overwhelming announcement, our merciless critic proceeds to indulge in the most cutting observations at our expense, likening us (as we fear sarcastically) to Solomon the Wise, and parodying our unhappy suggestion with the most lively ingenuity. Our readers will be anxious to know in what particular we have offended. It was in a note on the centenary of Arago (*The Electrician*, Dec. 17th, page 117). We there ventured to make this suggestion :—That inasmuch as a certain troublesome phenomenon, usually known under the name of Foucault, had first been observed by Arago and elucidated by Faraday, it might, with some propriety, be called the "Farrago." *Mais, si vous plait* M. le redacteur de *l'Ingenieur Electricien*, really this was only our fun; it was not due, as you are pleased to say, to our "ridiculous love of neologism" (!) but rather, in point of fact, to our neologistic weakness for the (occasional) ridiculous. We are well aware, however, that this is a very paltry excuse, and much trouble might have been avoided had we been content to follow the classic example of Artemus Ward, and written "N.B.—This is a goak." Our sapient critic proceeds to parody our ideas by suggesting that the ohm be henceforth called the "ohmlette"—a witticism which is in itself a demonstration of the superior sprightliness of the Gallic wit, with which, for our own part, we recognise the hopelessness of all further attempts to compete.

Electric Lighting of Collieries.—Mr. Charles Lever, writing to *The Times* on this subject, says :—"I have urged in your columns on many occasions the use of only the best lamps, and the prohibition of the use of gunpowder for blasting in coal mines. I have offered rewards for the best lamps—electrical and otherwise—and for a perfectly safe substitute for gunpowder. The latter is now an accomplished fact, and coal can now be safely blasted in the most fiery seam without fear of explosion. The lamp question may not yet be finally solved, but Mr. J. Wilson Swan, M.A., spent an evening at my house a few weeks ago, and I was delighted to see that he had invented an electrical, portable, safety lamp, burning in vacuum, giving an excellent light, and with a fire-damp indicator attached. This lamp—Mr. Swan's latest invention—I believe to be absolutely safe. Other effective and safe electrical lamps have been sent to me for inspection and experiment. These are 'as light is to darkness' compared with the dim glimmer of the old safety lamp still in use. Last month I had a long conversation with Sir Frederick Abel, the greatest authority of the present day on explosives, who was the leading scientific member of the Royal Commission on Accidents in Mines, and he is entirely of my opinion that the time is very near to us when the dark recesses of our coal mines will be brilliantly illuminated by means of perfectly safe, efficient, portable, and (in the best sense) economical electrical lamps. When this happy time arrives explosions will be rare, and the deaths from falls of roofs or sides of the workings, and other casualties which carry off the miners one by one will cease or be reduced to a minimum. I firmly believe that instead of 1,200 deaths in coal mines annually we shall not exceed 200, and instead of 90,000 miners, being injured every year the number may be reduced to less than 10,000. The better light afforded to the miners the greater their degree of safety. Darkness and danger are akin, and in coal mines especially frequently mean death."

A Thermo-Electric Study of the Phenomenon of Recalescence.—The term recalescence refers to the singular phenomenon of spontaneous re-heating which occurs during the cooling of cast iron or steel. This can best be seen by raising to a red heat a thin piece of iron or steel such as a needle. It may then be noticed that just as the red heat has died away there is a sudden return or rebound of the temperature, so that the iron again flashes into momentary redness. M. Osmond has recently undertaken the investigation of this subject by a thermo-electric method, in the laboratory of the Ecole des Mines at Paris. The particular object aimed at was to determine whether recalescence is due to the liberation of heat, owing to a modification of the molecular structure of the iron, or whether it is due to a chemical action upon the carbon. A thermo-electric couple, consisting of platinum and platinum-rhodium alloy was employed, with a d'Arsonval galvanometer. The curves of temperatures for various specimens of cast iron and steel of different hardnesses were examined during the period of cooling from a temperature of 800°. The amount of carbon present in the iron was 0·16 per cent. and in the steel it varied between 0·57 and 1·25 per cent. The following facts were ascertained as the result of the experiments :—(1) The temperature of recalescence rises when the amount of carbon is increased and the temperature of transformation of the iron falls, until in hard steel these two temperatures are coincident. (2) The rapidity with which heat is applied within the range of 1° in from two to ten seconds has no influence upon the critical points. (3) The critical points are a little lowered when we raise the initial temperature from which the cooling takes places from 736° to 840°. (4) The critical points lower themselves below the point of visibility when the first cooling is conducted with rapidity, as in the process of tempering. (5) During the annealing after tempering, the latent heat of tempering (?) is disengaged progressively and not suddenly. The author is of opinion that this method of studying iron and steel is likely to lead to important practical processes for determining the qualities of iron.

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THE PARIS BRUSSELS TELEPHONE LINE.—This line has now been completed throughout, and communication between the terminal stations has been successfully established. Before, however, the full advantage of the scheme can be realised in through communication between the subscribers to the local exchanges in the two cities, there remains a further problem to be solved. The Paris subscribers have the good fortune to enjoy complete metallic circuit communication, and no difficulty arises in placing them upon the trunk line. But at Brussels, where an earth circuit is in use, some form of relay or repeater becomes necessary before this connection can be made. Nothing has yet been decided in this matter, and although several forms of telephone repeaters have been devised, we are not aware that any definite success has been attained with such instruments up to the present time; and we shall therefore watch the development of the complete scheme with considerable interest. The Exhibition of Telephony, which is now open in Brussels, will not improbably be the means of providing a solution of the problem. It will be remembered that it was at one time proposed by the Belgian authorities to attempt to make use of the Van Rysselberghe system upon this line, and they even wished to employ a pair of previously existing iron wires. The French very naturally demurred to this, and in the end a pair of phosphor bronze wires were erected upon the same posts, the wires being crossed upon the method first employed by the English Post Office. These wires have a diameter of 3mm. and weigh 65 kilogrammes to the kilometre (say, 227lb. per mile), with a conductivity of 95 per cent. The total length of the line is 315 kilometres, and the resistance of each wire is 2·4 ohms per kilometre, or a total resistance of 1,512 ohms. The total cost of the line, excluding posts, amounted to 85,000fr. Now that the line itself has been built to meet the exigencies of telephonic, rather than telegraphic, communication, the question of employing it for the latter purpose also by means of the Von Rysselberghe system assumes a different aspect, and this, we believe, will shortly be done. The tariff has been fixed at three francs for five minutes' conversation.

A SAD FATALITY.—We very much regret to record a sad accident which took place in connection with the extensive installation of the Grosvenor Gallery Electric Supply Company. The circumstances are surrounded with some degree of mystery, if the evidence tendered at the inquest is to be implicitly received. One thing, however, is rendered certain, both by the medical evidence and the verdict of the jury—namely, that the death of the unfortunate victim was not due to an electric shock, but was caused by a fall from the roof of the premises. The evidence given at the inquest was as follows:—"Mr. Mortimer Davis, a tobacconist, carrying on business at 84, Regent-street, deposed that the deceased was his errand boy. On the 3rd instant witness was returning home to dinner at half-past six, and on passing the premises of Messrs. Gerrard and Co., florists, which adjoin his own, he noticed that the electric light was out, and some one was lighting the gas. Witness went indoors and was met by an overpowering smell of burning varnish and wood. Almost immediately afterwards he saw a tremendous flame shoot out of the closet window next door. He then ran into Messrs. Gerrard's and heard several loud explosions, and flames flew out to a distance of about 10ft. As there was nobody present who knew how to cut off the electric current witness went to Vine-street Police-station, where an inspector advised him to send to the Grosvenor Gallery. Witness despatched a messenger thither, but, in the interim, fearing the premises would catch fire, he gave the deceased a pair of shears and told him to get out of the first-floor window and cut the electric light wire. He said he could do it better on the roof, and before witness could speak he had got to the top of the house. The flame and explosions suddenly ceasing, witness concluded that the current had been turned off at the Gallery. A moment later he heard a crash, and eventually discovered that the deceased had fallen through a skylight from a height of 60ft. He was found in the cellar quite dead. In reply to Mr. Hayward witness said the flames he had spoken of were absolute fire, and not merely reflection. Everybody was very much excited.—Dr. J. R. Kemp, of 101, Regent-street, who made a post-mortem examination, said the cause of death was a fracture of the skull and concussion of the brain. He was quite satisfied that the unfortunate lad was not killed by the electric current. There were always peculiar symptoms in cases of death by electricity.—Mr. G. L. Addenbrooke, 9, Mecklenburgh-street, engineer in the service of Sir C. Lindsay and Co., said the business was known as the Grosvenor Gallery Electric Light Supply. It was formed for the supply of the electric light to general consumers. He had examined the house where the accident happened, and found at the point where the wires entered the premises that a spark had passed two or three times and slightly blistered the paint. Water had come through the roof of the closet in considerable quantities, and had saturated the wires at the point where they entered the fuse box, and the proximity of the water seemed to have allowed an intermittent passage of a slight current. If the current had attained great dimensions the fuse in the engine room would have given way, and the supply have been immediately cut off. In cutting through the gutta percha covering of the wire the deceased might or might not have received a shock of a slight character. The flame which Mr. Davis and the police-constable had described would be an electric spark 4in. long, and blinding in its nature. Any one looking at it would think it was a flame. The shears the deceased was using would act as a conductor, but as the current would be only the "leakage to earth," the shock would be very small indeed, and not sufficient to destroy life. The explosions which had been spoken of would be caused, he thought, by the spark igniting water which had been decomposed by the current. —John Rahter, an assistant in the employ of Messrs. Gerard and Co., said he was coming downstairs when he saw bright flames issuing from the closet in which the battery was kept. He attempted to turn off the supply, but failed, and Mr. Davis coming into the shop suggested to witness to cut the wires, or the shop would be burned down. Witness replied that it would be dangerous to cut the wires, but Mr. Davis took a pair of shears into his own shop and sent the lad to cut them. In answer to the jury, witness said that the flames issuing from the battery seemed like real fire. After further evidence the jury returned a verdict to the effect that the deceased was killed by a fall from the roof of the premises; there was not sufficient evidence to show whether he received an electric shock or not. They also wished to state that the electric light companies should supply their customers with printed rules warning them of the danger attached to meddling with the electric wires." We confess our inability to account satisfactorily for these "flames 10ft. long" and the series of loud explosions which Mr. Davis bore witness to. It is scarcely possible to admit Mr. Addenbrooke's suggestion as to the explosion being due to gas, resulting from the decomposition of water. Under practical conditions an alternating current is of course unable to decompose water. A much more feasible hypothesis is that the gas fittings were to blame and the explosions were due to coal gas, ignited by a spark at the place where the fault in the insulation was afterwards discovered.

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 187.)

Ruhmkorff's induction coil consists of a primary coil surrounding a soft iron core. The current in this coil is made intermittent by means of a spring carrying a small piece of iron, which is in front of one end of the core, and which is attracted by the magnetism of the core as soon as the current flows, and, moving in obedience to this attraction, breaks a contact between a small piece of platinum attached to the spring and a piece of platinum on the end of an adjustable screw, thus stopping the current, destroying the magnetism, and allowing the spring to return and again make contact. Sometimes separate clock-work breaks, or tuning forks, are used in place of the vibrator, to render the current intermittent. Around the primary coil is wound a great length of fine wire, constituting the secondary coil. The coefficient of mutual induction between the primary and secondary wires will be nearly proportional to the number of turns in the secondary coil, and may, therefore, be made very great. When contact is made in the primary circuit the current will begin to flow, and will steadily increase in the primary coil. The induced electromotive force in the secondary will be proportional to the rate of increase of the primary current. This will depend on the electromotive force of the battery, but will be retarded by the self-induction of the primary coil, with its iron core, and cannot, therefore, be made very great. Hence, the electromotive force of the secondary coil, when the primary current is started, can never be very great.

On breaking the primary circuit, however, the current can be stopped comparatively quickly by causing the contact breaker to move sufficiently rapidly, and thus to throw into the circuit a very great air resistance in a very small fraction of a second. Thus, the primary current can be stopped much more quickly than it was generated, and a correspondingly greater electromotive force may be generated in the secondary coil.

But, however quickly the vibrator may move, there must be an amount of work done by the current before it ceases equal to that done by the battery against the opposing electromotive force of self-induction in starting the current, and consequently the primary current will leap over any space of air rather than cease suddenly on breaking contact, and will continue for a certain interval before it is completely dead. Hence, a contrivance is adopted in the Ruhmkorff coil by which the primary current may expend its energy very rapidly. This consists in connecting a condenser of very great capacity with the terminals of the primary coil. On breaking contact in the primary circuit the electromotive force of self-induction, instead of sending a current across the gap where the contact is broken, sends a current into the condenser, charging it up to a high potential, and, as it meets with no sensible resistance, it expends its energy in charging the condenser in a very short time indeed, and then ceases. Thus the rate of diminution of the primary current is very great indeed, and the electromotive force in the secondary correspondingly increased. Moreover, as soon as the primary current ceases, the charged condenser produces a reversed current in the primary until it has discharged itself, thus prolonging the electromotive force in the secondary. By this contrivance the sparks at the contact breaker are very much diminished, while an electromotive force is obtained in the secondary coil capable of sending spark discharges through great lengths of air. This explains why long sparks can be obtained from an induction coil when the primary circuit is broken, but not when it is made.

The induction in a Ruhmkorff coil might be rendered more complete by connecting the ends of the iron core by means of iron bars passing longitudinally along the outside of the secondary coil, so that the lines of force of the primary coil may have a complete circuit in iron embracing both coils.

If the terminals of the secondary coil be connected with the coatings of a Leyden jar the sparks obtained will be brighter, on account of the accumulation of electricity, but not so long.

When an electric current is employed to produce motion in a conductor in a magnetic field, we have seen that an electromotive force is induced in the conductor, which opposes the current, and thereby causes its diminution. The work done by the current against this opposing electromotive force represents the useful mechanical work done in moving the conductor. The work so done in a unit of time is proportional to the opposing electromotive force and to the strength of the current. Thus the work done by the agent which transmits the current consists of two parts, one of which is employed in doing useful work in driving the "motor," while the other part is wasted in the production of heat caused by the passage of the current. If E denote the electromotive force urging the current, e the opposing electromotive force induced by the motor, and C the current, the whole work done in sending the current will be E C; and of this e C will represent the useful work done on the motor, while (E − e) C will represent the energy wasted in the circuit on account of electrical resistance. For, the resultant electromotive force in the circuit, from which the current is determined by Ohm's law, is E − e, and the work done against electrical resistance by this E.M.F. in sending a current C, which is equal to $\frac{E-e}{R}$, must be (E − e) C.

The efficiency of the system is represented by the ratio of the mechanical work done on the motor to the whole work expended in producing the current, and this is equal to the ratio of e C to E C, or $\frac{e}{E}$. In order to gain the greatest efficiency e should be made as large as possible in comparison with E. The rate at which work is done upon the motor (measured in *watts*) is e C, the electromotive force being expressed in volts and the currents in amperes. Expressed in horse-power it is $\frac{eC}{746}$ nearly. If R denote the resistance of the whole circuit, C is equal to $\frac{E-e}{R}$. Hence the rate of doing work upon the motor is represented by $\frac{e(E-e)}{R}$. If e be nearly equal to E this expression becomes very small, so that the horse-power of the motor becomes very small, unless R, the resistance of the whole circuit, is correspondingly reduced. Hence, when the resistance of the circuit is given, a great rate of doing work, or horse-power, is inconsistent with a high rate of efficiency. The greatest horse-power in the motor is obtained by making e equal to $\frac{1}{2}$ E when E is given. In this case one half of the work done in driving the current appears as mechanical work done upon the motor, and the other half is wasted as heat produced by the electrical resistance of the circuit, so that the efficiency of the system is one-half. If we consider only the electrical conditions and neglect mechanical resistance altogether the greatest efficiency will be obtained by making e sensibly equal to E. This may be done by sufficiently increasing the speed of the motor. For this purpose the couple which resists the rotation of the armature of the motor must be very small, and notwithstanding the high speed of the motor the work done by it in a second will be very small on account of the smallness of the current, unless the resistance of the circuit be extremely small. Of course if we take into account the mechanical resistance of the motor (arising from friction, &c.), we find that at high speeds a very large percentage of the work done in driving the motor is wasted by its own internal friction, &c., and this assigns a speed for maximum efficiency much less than that which would reduce the current to zero. In order to obtain a high rate of efficiency with great horse-power we must make the electrical resistance of the circuit as small as possible. We should always employ as large an electromotive force, E, as can be secured with the low resistance of the circuit, and drive the motor at high speed so as to make the ratio of e to E considerable.

In the above investigation we have supposed our motor theoretically perfect, for no theory will allow us to neglect the electrical resistance of the circuit. In many motors, as in most dynamos, the revolving armature is furnished with an iron core. In this core induced currents are set up which oppose the motion of the armature, and the work done against this

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resistance appears as heat in the armature itself. The iron is used in order to concentrate the magnetic field upon the armature and thus increase the horse-power of the arrangement, but the work done against the currents induced in the iron is absolutely wasted, and thus diminishes the efficiency of the system. There may also be a considerable amount of work done in changing the magnetism of the iron as the armature revolves, and this also will be wasted and detract from the efficiency of the system. The evil effect of the currents induced in the iron is reduced to a minimum in the Gramme machine by employing iron wire instead of continuous metal in the armature, so that the induced currents tend to pass through the iron at right angles to the axis of the wire and thus meet with great resistance in passing from strand to strand. In consequence of this the induced currents are always very small, but the magnetic lines of force pass through the armature along the wires and thus meet with little resistance, or, in other words, find a path of great magnetic permeability. In the Edison armature the iron is in the form of thin discs, which are separated from each other by sheets of paper which prevent induced currents while the magnetic lines of force pass across the armature in the planes of the disc. In some motors and dynamos iron is altogether dispensed with in the armatures, and the magnetic field is sufficiently concentrated upon the wire of the armature by special arrangements of the field-magnets. When much power is lost by induced currents in the armature the evil is indicated by a corresponding rise of temperature. Most of the machines referred to above are generally used for the production of currents rather than as motors, but all dynamos or magneto electric machines which produce a continuous current in one direction are reversible, and can be used as motors, and the same remarks apply to the action of the iron in either case. In the large Edison dynamos a blast of air is driven by a fan around the armature to prevent a rise of temperature which would be injurious to the insulating material.

(To be continued.)

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXV.

BY OLIVER HEAVISIDE.

(Continued from page 145.)

The Transfer of Energy and its Application to Wires. Energy Current.

When the sage sits down to write an elementary work he naturally devotes Chapter I. to his views concerning the very foundation of things, as they present themselves to his matured intellect. It may be questioned whether this is to the advantage of the learner, who may be well advised to "skip the Latin," as the old dame used to say to her pupils when they came to a polysyllable, and begin at Chapter II. If this be done, Prof. Tait's "Properties of Matter" is such an excellent scientific work as might be expected from its author. But Chapter I. is metaphysics. There are only two Things going, Matter and Energy. Nothing else is a thing at all; all the rest are Moonshine, considered as Things.

However this be, the transfer of energy is a fact well known to all, even when we put the statement in such a form that the energy seems to lose its thinginess, by calling it the transfer of the power of doing work. Thus, after transfer of energy from the sun ages ago, followed by long storage underground and convection to the stove or furnace, we set free the imprisoned energy, to be generally diffused by the most varied paths. The transfer from place to place can be, in the great measure, traced so far as quantity and time are concerned; but it does not seem possible to definitely follow the motion of an atom of energy, so to speak, or to give a fixed individuality to any definite quantity of energy.

Whenever the dynamical connections are known, the transfer of energy can be found, subject to a certain reservation. In the elementary case of a force, F, acting on a particle of mass m and velocity v, F is measured by the rate of acceleration of momentum, or $F = m\dot{v}$; and, to obtain the equation of activity, we merely multiply this equation by the velocity, getting $Fv = mv\dot{v} = \dot{T}$, the rate of increase of the kinetic energy T, or $\frac{1}{2}mv^2$, which is the amount of work the particle can do against resistance in coming to rest. Where the energy came from is here left unspecified. In a case of impact we may clearly understand that the transfer of kinetic energy is from one of the colliding bodies to the other through the forces of elasticity brought into play, thus making potential energy an intermediary, though what the potential energy may be, and whether it is not itself kinetic, or partly kinetic, we are not able to decide.

It is much more difficult in the case of gravity. As the stone falls to the ground, it acquires kinetic energy truly; and if energy moves continuously, as its indestructibility seems to imply, it must receive its energy from the surrounding medium; or the energy of gravitation must be in space generally, wholly or in part, and be transferred through space by definite paths through stresses in the medium, by which means Maxwell endeavoured to account for gravitation. In general, we have only to frame the equations of motion of a continuous system of forces, and it stands to reason that the transfer of energy is to be got by forming the equation of activity, not of the system as a whole, but of a unit volume.

Now, in the admirable electromagnetic scheme framed by Maxwell, continuous action through space is involved, and the kinetic and potential energies (or magnetic and electric) are definitely located, as well as the seat and amount of dissipation of energy. We therefore need only form the equation of activity to find the transfer of energy vector. Of course impressed forces are subject to the energy definition. No other is possible in a dynamical system.

But if we take Maxwell's equations and endeavour to immediately form the equation of activity (like $Fv = \dot{T}$ from $F = m\dot{v}$), it will be found to be impossible. They will not work in the manner proposed. But we may consider the energy, electric and magnetic, entering and leaving a given space and that dissipated within it, and by laborious transformations evolve the expression for the vector transfer. This was first done by Prof. Poynting for a homogeneous isotropic medium (*Phil. Trans.*, 1884). In my independent investigation of this matter, I also followed this method in the first place (*The Electrician*, June 21, 1884) in the case of conductors. But the roundabout nature of the process to obtain what ought to follow immediately from the equations of motion, led me to remodel Maxwell's equations in some important particulars, as in the commencing sections of this article (Jan., 1885) with the result of producing important simplifications, and bringing to immediate view useful analogies which are in Maxwell's equations hidden from sight by the intervention of his vector potential. This done, the equation of activity is at once derivable from the two cross connections of electric force and magnetic current, magnetic force and electric current, in a manner analogous to $Fv = \dot{T}$, without roundabout work, and applicable without change to heterogeneous and heterotropic media, with distinct exhibition of what are to be regarded as impressed forces, electric and magnetic. (*Electrician*, Feb. 21, 1885).

Knowing the electric field and the magnetic field everywhere, the transfer of energy becomes known. The vector transfer at any place is perpendicular to both the electric and the magnetic forces there, not counting impressed forces. Its amount per unit area equals the product of the intensities of the two forces and the sine of their included angle.

But I mentioned that there is a reservation to be made. It is like this. If a person is in a room at one moment, and the door is open, and we find that he is gone the next moment, the irresistible conclusion is that he has left the room by the door. But he might have got under the table. If you look there you can make sure. But if you are prevented from looking there, then there is clearly a doubt whether the person left the room by the door or got under the table hurriedly. There is a similar doubt in the electromagnetic case in question, and in other cases. Thus, we can unhesitatingly conclude from the

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properties of the magnetic field of magnets that the mechanical force on a complete closed circuit supporting a current is the sum of the electromagnetic forces per unit volume (vector product of current and induction), but it does not follow strictly that the so-called electromagnetic force is the force really acting per unit volume, for any system of forces might be superadded which cancel when summed up round a closed circuit.

So, in the transfer of energy case, there may be any amount of circulation of energy in closed paths going on (as pointed out in another manner by Prof. J. J. Thomson), besides the obviously suggested transfer, provided this superposed closed circulation is without dissipation of energy. Or, if W be the vector energy current density, according to the above-mentioned rule, we may add to it another vector, say *w*, provided *w* have no convergence anywhere. The existence of *w* is possible, but there does not appear to be any present means of finding whether it is real, and how it is to be expressed.

Its consideration may seem quite useless, in fact. But it is forced upon us in quite another way, by the fact that when $w=0$ we are sometimes led to the closed circulation of energy. Let, for instance, a magnet be placed in the field of an electrified body; or, more simply, let a magnet be itself electrified. There is no waste of energy; hence the flow of energy caused by the coexistence of the two fields, electric and magnetic, is entirely in closed paths, which, in the case of a spherical uniformly magnetised body, uniformly superficially electrified, are circles in parallel planes perpendicular to the axis of magnetisation, the circles being centred on this axis. This closed circulation is entirely through the air or other dielectric. What is the use of it? On the other hand, what harm does it do? And if the medium is really strained by coexistent electric and magnetic stresses, why should there not be this closed circulation? But, if we like, we may cancel it by introducing the auxiliary *w*.

There is yet another kind of closed circulation, according to W alone, not existing by itself, but set going by impressed forces causing a useful transfer of energy, and ceasing when the useful transfer ceases. If, for instance, we close a conductive circuit containing a battery, we set up a useful transfer from the battery to all parts of the wire, through the dielectric usually. Suppose there is also impressed electric force in the dielectric, or electrification, or any stationary electric field. If the battery does not work there is no transfer of energy. But when it does, there is, besides the regular first mentioned transfer from the battery to the wire, a closed circulation due to the coexistence of the stationary electric field and the magnetic field of the wire current, the resultant transfer being got by superposing the regular and the closed circulations. Here again, by introducing *w*, we may reduce it to the regular undisturbed transfer. It is clear, then, in considering the nature of the transfer in a useful problem, that it is of advantage to entirely ignore the useless transfer, and confine our attention to the undisturbed.

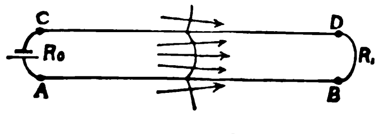
A general description of the transfer along a straight wire was given in Section II. (January 10, 1885). It takes place, in the vicinity of the wire, very nearly parallel to it, with a slight slope towards the wire, as there described. Prof. Poynting, on the other hand (Royal Society, *Transactions*, February 12, 1885), holds a different view, representing the transfer as nearly perpendicular to a wire, *i.e.*, with a slight departure from the vertical. This difference of a quadrant can, I think, only arise from what seems to be a misconception on his part as to the nature of the electric field in the vicinity of a wire supporting electric current.

The lines of electric force are nearly perpendicular to the wire. The departure from perpendicularity is usually so small that I have sometimes spoken of them as being perpendicular to it, as they practically are, before I recognised the great physical importance of the slight departure. It causes the convergence of energy into the wire. To estimate the amount of departure, we may compare the normal and tangential components of electric force. Let there be a steady current in a straight wire, and the fall of potential from beginning to end be $V_0 - V_1$; the tangential component is then $(V_0 - V_1) \div l$, if l be the length of wire. On the other hand, the fall of potential from the wire to its return, of no resistance, for simplicity, at any distance from the beginning of the line, is V, which is V_0 at one end and V_1 at the other. It is clear at once that the tangential is an exceedingly small fraction of the normal component of electric force, if the wire be long, and that it is only under quite exceptional circumstances anything but a small fraction. Prof. Poynting should therefore make his tubes of displacement stick nearly straight up as they travel along the wire, instead of having them nearly horizontal, unless I have greatly misunderstood him.

But if we distribute the impressed force uniformly throughout the circuit, so that there shall be, in the steady state, no difference of potential and no transfer of energy, owing to the impressed force at any place being just sufficient to support the current there—then, on starting the impressed force, the transfer of energy will be perpendicular to the wire outward, ceasing when the steady state is reached; and, on the other hand, on stopping the impressed force the transfer will be perpendicular to the wire inward, the magnetic energy travelling back again (assisted by temporary longitudinal electric force, which has no existence in the steady state) to be dissipated in the wire. But this case, though imaginable, is not practically realisable.

In the vicinity of the wire the radial electric force varies inversely as the distance, and so does the intensity of magnetic force. The density of the energy current therefore varies inversely as the square of the distance approximately. This does not continue indefinitely. Thus, if the return be a parallel wire the middle distance is the place of minimum density of the energy current, in the plane of the two wires. As regards the total energy current, this is VC, the product of the fall of potential from one wire to the other into the current in each. One factor, V, is the line integral of the electric force across the dielectric. The other, C, is the line integral $(\div 4\pi)$ of the magnetic force round either wire.

In the figure *ab* and *cd* are the two wires, enormously shortened in length compared with their distance apart, joined



through terminal resistances R_0 and R_1, in the former of which alone is the impressed force *e*. The fall of potential from *a* to *c* is V_0, from *b* to *d* is V_1, and at any intermediate distance is V. The total activity of the source is eC, of which $(e - V_0)$ C is wasted in R_0. What is left, or V_0C, is the energy current at *ac*, entering the line. By regular waste into the wires, its strength falls to V_0C at *bd*, where the line is left, and the terminal arrangement entered, to be wasted in frictional heat generation R_1C^2 therein, or otherwise disposed of. The curved lines and arrows perpendicular to them show lines of electric force and the direction of the energy flow at a certain place, the inclination of the lines of force to the perpendicular being greatly exaggerated, as well as that of the lines of flow of energy to the horizontal, in order to show the convergence of energy upon the wires, there to be wasted. Its further transfer belongs to another science.

The rate of decrease of VC as we travel along the line is the waste per unit length. Thus,

$$-\frac{d}{dx}(\mathrm{VC}) = -\mathrm{C}\frac{d\mathrm{V}}{dx} = (\mathrm{R}_1 + \mathrm{R}_2)\mathrm{C}^2 \quad . \quad . \quad (81b)$$

R_1 and R_2 being the resistances of the wires per unit length. This is in steady flow, with no leakage. But if there be leakage, we have the equation of continuity

$$-(d\mathrm{C}/dx) = \mathrm{KV},$$

making

$$-\frac{d}{dx}(\mathrm{VC}) = \mathrm{KV}^2 + (\mathrm{R}_1 + \mathrm{R}_2)\mathrm{C}^2 \quad . \quad . \quad . \quad (82b)$$

where KV^2 is the waste heat per second due to the leakage resistance.

But when the state is not steady, we have the equation of continuity

$$-\frac{d\mathrm{C}}{dx} = \mathrm{KV} + \mathrm{S}\dot{\mathrm{V}} \quad . \quad . \quad . \quad (80b)\ bis.$$

and the equation of electric force

$$-\frac{d\mathrm{V}}{dx} = \mathrm{L}_0\mathrm{C} + \mathrm{E} - \mathrm{F} \quad . \quad . \quad (73b)\ bis.$$

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so that

$$-\frac{d}{dx}(\mathrm{VC}) = \mathrm{KV}^2 + \frac{d}{dt}(\tfrac{1}{2}\mathrm{SV}^2) + \frac{d}{dt}(\tfrac{1}{2}\mathrm{L}_0\mathrm{C}^2) + \mathrm{EC} - \mathrm{FC} \qquad (83)$$

Here we account for the leakage heat, for the increase of electric energy, and for the increase of magnetic energy in the dielectric by the first, second, and third terms on the right side. EC, the fourth term, represents the energy entering the first wire per second, E being the tangential electric force; and – FC, the last term, represents the energy entering the second wire per second, F being the tangential electric force at its boundary reckoned the same way as E. The energy flow is now perpendicular to the current, *i.e.*, after entering the wires, ceasing when the axes are reached. And,

$$\mathrm{EC} = \mathrm{Q}_1 + \dot{\mathrm{T}}_1, \qquad -\mathrm{FC} = \mathrm{Q}_2 + \dot{\mathrm{T}}_2 \quad . \quad . \quad (84b)$$

if Q_1, Q_2 are the dissipativities, T_1 and T_2 the magnetic energies in the two wires, per unit length of line.

If the impressed force is a S.H. function of the time, so is the current, &c., everywhere, and

$$\mathrm{E} = \mathrm{R}'_1\mathrm{C} + \mathrm{L}'_1\dot{\mathrm{C}}, \qquad -\mathrm{F} = \mathrm{R}'_2\mathrm{C} + \mathrm{L}'_2\dot{\mathrm{C}} \quad . \quad (85b)$$

where R_1', R_2', L_1', and L_2' are constants depending upon the frequency, reducing to the steady-flow resistances and inductances when the frequency is infinitely low. In this S.H. case

$$\mathrm{Q}_1 = \tfrac{1}{2}\mathrm{R}'_1\mathrm{C}_0^2, \quad \mathrm{Q}_2 = \tfrac{1}{2}\mathrm{R}'_2\mathrm{C}_0^2, \quad \mathrm{T}_1 = \tfrac{1}{4}\mathrm{L}'_1\mathrm{C}_0^2, \quad \mathrm{T}_2 = \tfrac{1}{4}\mathrm{L}'_2\mathrm{C}_0^2,$$

are the *mean* dissipativities and magnetic energies in the wires, C_0 being the amplitude of the current; the halving arising from the mean value of the square of a sinusoidal function being half the square of its amplitude. But in no other case is there anything of the nature of a definite resistance, although, if the magnetic retardation to inward transmission is small, we may ignore it altogether, and drop the accents in (85*b*).

(To be continued.)

CORRESPONDENCE.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the last issue of your journal I find notice given of a storage cell brought out by the "Union Electrical Power and Storage Company," which apparently consists, as to the negative plates, of an agglomerated mass of peroxide of lead fixed in frames or edgings of celluloid, and, as to the positives, of spongy metallic lead similarly framed, but with the addition of strips of lead; electrical contact being made by a strip of platinum.

May I ask you to publish for general information the following epitomised extracts from one of my early patents, No. 5,631 of 1881, being the third taken out by me in that year, in which I describe plates, supports, retainers, or frames of any suitable form for the retention of active material (upon, or in which the active material may be fixed or placed in a finely divided pasty, deposited or compound condition), constructed of materials not readily subjected to the destructive influence of oxidation or other destructive action, and specifying, amongst other materials, "cellulose, either alone or in combination with platinum, such combination forming a terminal." My claim reads as follows:—"The construction of terminal plates, supports, retainers, or frames employed in secondary batteries, of a material not readily subjected to the destructive influence of oxidation in the manner and for the purpose herein described."—Yours, &c., JOHN S. SELLON.

January 12th, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My company have been informed that the Electrical Power Storage Company have to-day written a letter to the Union Electrical Power and Light Company stating that the batteries referred to in a printed description issued by the latter company are an infringement of certain patents held by the Electrical Power Storage Company.

As my company have sold the Letters Patent under which these batteries are made to the Union Company, I am instructed to say that such batteries are not an infringement of any Letters Patent owned by the Electrical Power Storage Company, and, furthermore, that within the last month Counsels' opinions have been taken and careful investigation of specifications have been made at the patent office, both of which clearly show that the Electrical Power Storage Company's patents are not novel, have been anticipated, and are consequently invalid so far as they have anything in common with the patents sold to the Union Company.

The Union Company are, I understand, prepared to defend any proceedings that the Electrical Power Storage Company may see fit to take, and so are we. The Electrical Power Storage Company must be aware from past experience that the position they take up is untenable.—Yours, &c.,

By order, D. ARMYTAGE DAVIS, Secretary.

Primary Battery Company, Limited, 11, Queen Victoria-street, London, E.C., January 13th, 1887.

WALKER'S SULPHUR SAL-AMMONIAC BATTERY.

We are informed by Mr. Sydney Walker that he has invented a battery which he describes in the following terms: "This battery is exactly similar to the Leclanché, except that in place of the oxide of manganese used as a depolariser, pure sulphur of the size of a pea or small bean is used; and that the proportion of sulphur required is smaller, both by weight and by volume than that of the oxide of manganese generally employed. Its E.M.F. is a trifle below that of the porous cell Leclanché, while its resistance is very much less. The internal resistance and life of the cell can be varied within large limits by altering the proportions of sulphur and carbon employed. More sulphur gives a longer life for given work and higher resistance, more carbon gives lower resistance and shorter life. The ordinary life is about the same as Leclanché. The cell also possesses the valuable property of giving warning when it is worked out, or if subjected to an undue strain. In the working of the battery sulphuretted hydrogen is formed; but does not come away unless the battery is worked very hard, or is nearly worked out, so that warning is given in the case of leakage, on house bell wires say, that will be very valuable. The amount of the gas given off is never sufficient to be noxious, even under the conditions named.

The action of the cell appears to be as follows:—

Starting with	$2Zn$,		$2NH_4Cl$,	S,	C.
First	Zn,	$ZnCl_2$,	$2NH_3$,	H_2S,	C.
Next	Zn,	ZnS,	2HCl,	$2NH_3$,	C.
Next	Zn,	ZnS,	$2NH_4$	Cl,	C.

so that the whole of the work of the cell is done at the expense of the sulphur."

[Mr. Walker, of course, does not mean to overlook the expenditure of zinc —ED. *E.*]

MAGNETIC ORE SEPARATOR.—This apparatus, designed by J. Wenström, of Stockholm, for the concentration of magnetic iron ore, consists of a stationary electro-magnet supported by two spindle axes in a wooden stand. The magnet consists of an excentric iron cylinder provided with flanges, between which the conducting wire is wound in such a way that the current forms the north and south poles at the outer edges of the flanges, the adjacent flanges having different polarity. The current is conducted from a dynamo into the apparatus by means of insulated wires through one of the spindles. Around the magnet a drum rotates on the spindles. The drum consists of a number of parallel soft iron rods separated from each other by wood. The ore enters at the top of the drum, and follows its rotation; the non-magnetic portions falling after a quarter revolution, and the magnetic ore being firmly held by the magnetic iron rods. After another quarter revolution this falls into the ore hutch. Ore intimately associated with gangue must be first comminuted and washed. The ore obtained in a recent trial was, in volume, somewhat more than half of the material treated. The deads were not weighed.—*Journal* Inst. Civ. Eng.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes	205
Elementary Electricity and Magnetism—II. (Continued.)	210
Electromagnetic Induction and its Propagation. By Oliver Heaviside. (Continued.)	211
Correspondence	213
Walker's Sulphur Sal-Ammoniac Battery	213
RETROSPECT OF THE PAST YEAR (Illustrated.)	214
On the Conductivity of Mixtures of Aqueous Acid Solutions. By Dr. Svante Arrhenius	217
Society of Telegraph-Engineers and Electricians.—Presidential Address	219
The Self-Induction and Resistance of Compound Conductors. By Lord Rayleigh, D.C.L. (Continued.)	222
Electric Street Cars	223
The Electric Telegraph	225
Companies' Reports—	
The Eastern Telegraph Company	226
The Direct United States Cable Company	226
Companies' Share List	226

1886.

Continuing our description of some of the latest types of the Crompton dynamos, we come to the machine illustrated in Fig. 11, which is designed for electro-plating work in series. This machine has an output of 54 units, equal to 72·5 electrical horse-power. At 700 revolutions it yields 110 volts at the terminals, and 490 amperes, requiring 80·25 horse-power on the driving pulley. The commercial efficiency is thus 90·3 per cent., the electrical efficiency is 94·5 per cent., and the total efficiency of conversion is 97 per cent. The machine weighs $2\frac{1}{2}$ tons, and contains 1,030lbs. of copper. This gives 10·4 watts per lb. of total weight, and 52 watts per lb. of copper. The measurement is 6ft. 2in. by 5ft. 10in. by 2ft. 6in. The field is compound-wound for constant potential, the magnets, four in number, being forged of the best scrap iron, and weighing 1 ton 15cwt. The total ampere turns on the field coils amount to 11,600, of which 9,200 are supplied by the shunt coils. The current in the shunt coils equals 11·5 amperes, and in the series coils 123 amperes *each*. The resistance of the shunt coils as connected is 8·8 ohms, and that of the series coils is ·005 ohm. The armature is of the Gramme ring type, and has the following dimensions:—Axial length, 15·5in.; diameter, 15·5in.; radial depth, 3·125in. It contains 111 yards of bar or strip copper of an *average* sectional area equal to ·15 square inch, and a resistance between the brushes of ·004 ohm. The current density is 1,600 amperes per square inch, and 1,280 watts are lost in the armature with full load. The armature has only one turn for each of the 96 sections of the commutator. The weight of iron in the armature is about 5cwt., and of copper 206lb. This gives 262 watts per lb. of armature copper, and 1 volt per yard of conductor. The armature field is equal to 18 lines per square inch. The peripheral velocity is 2,840ft. per minute, and the bearings are 10in. in length, of cast iron, with white metal run in.

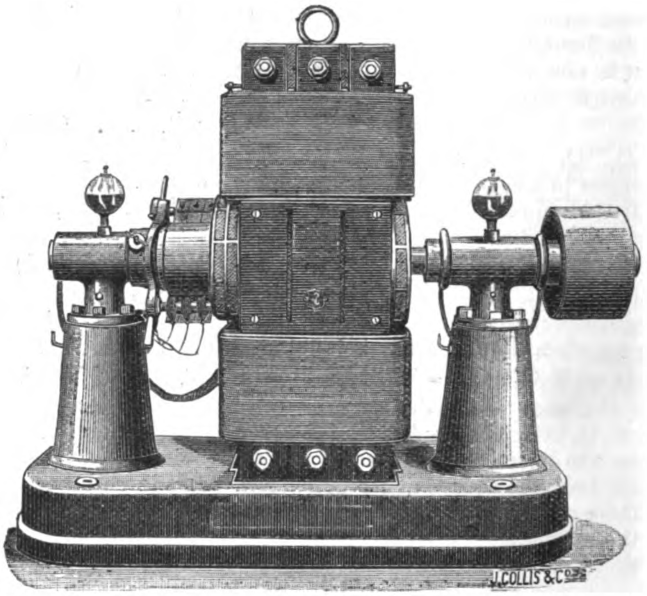

FIG. 11.—The Crompton Plating Dynamo.

In the armature of this machine Mr. Crompton has introduced an improvement, with a view to reducing the loss due to Foucault currents in the bars. The plan adopted is illustrated in Fig. 12.* It will be seen that the method adopted consists in splitting each bar in half longitudinally and crossing one half under the other at the central section. This does not, of course, entirely obviate the production of Foucault currents, but by halving these currents in each section of the bar the watts lost are, of course, reduced to one fourth for each half. The sections in Fig. 12 will readily be understood without further explanation.

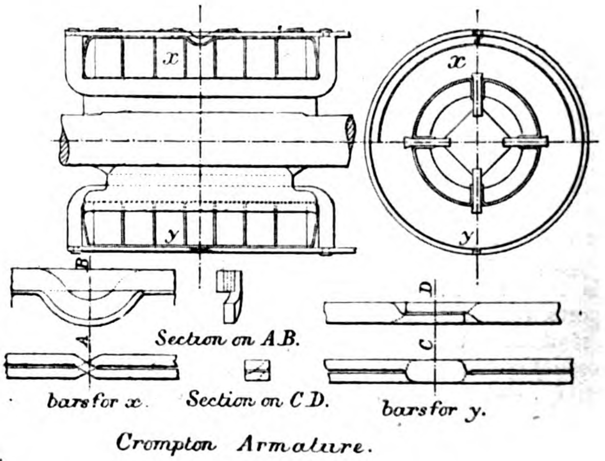

FIG. 12.

We have not yet exhausted the whole of the information with which this firm has kindly supplied us, but we propose at this point to give, for the sake of comparison, an example of recent practice by one of the largest firms of dynamo builders upon the Continent.

* This figure was inserted in error in our last week's issue.

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Messrs. PATERSON and COOPER construct the machines of the different types illustrated herewith. It will not be necessary to enter at length into the construction of these Phœnix machines, as they have been frequently described. Fig. 13

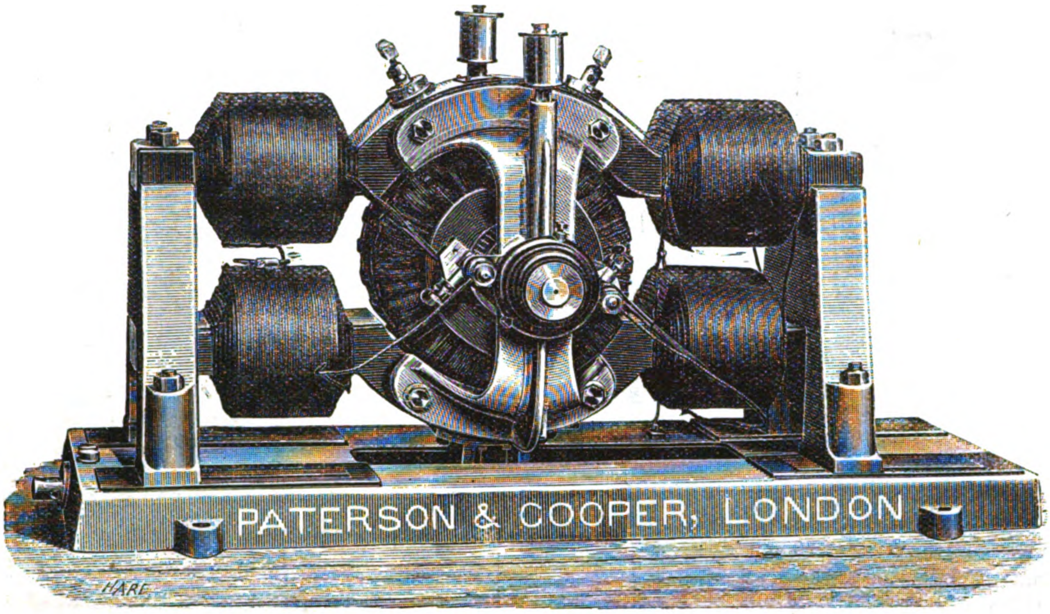

FIG. 13.—Phœnix Arc Light Dynamo.

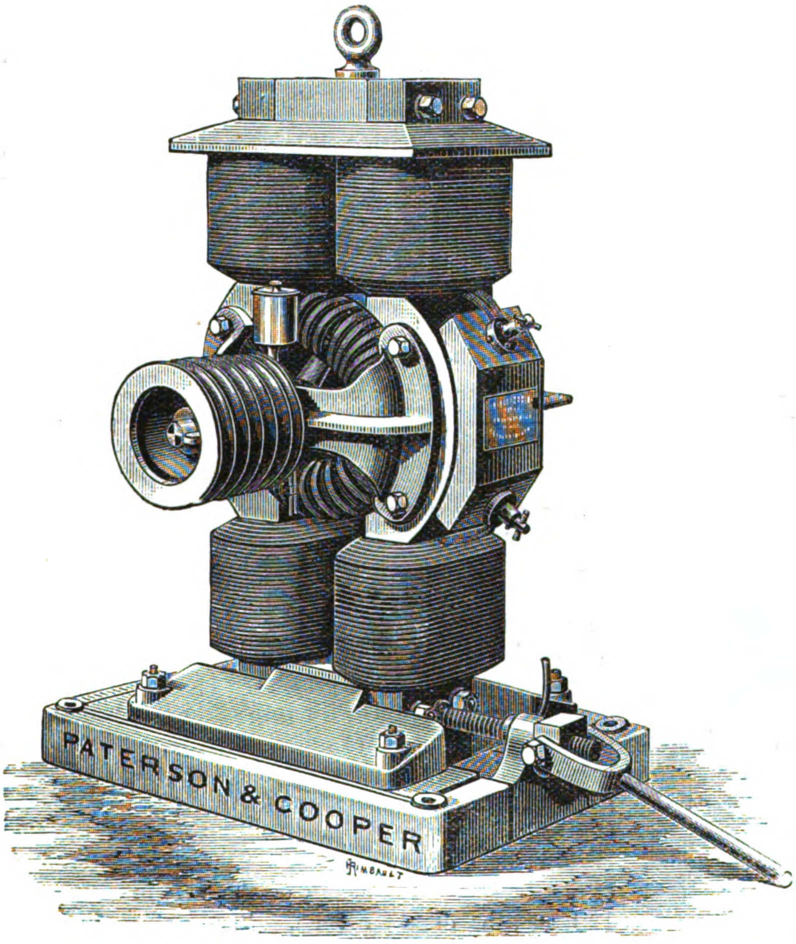

FIG. 14.—Vertical Phœnix Dynamo, driven by Belts.

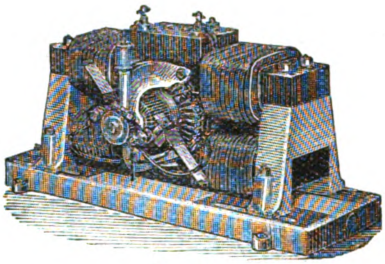

FIG. 15.
Horizontal Phœnix Dynamo, supplying 125 60-watt Lamps

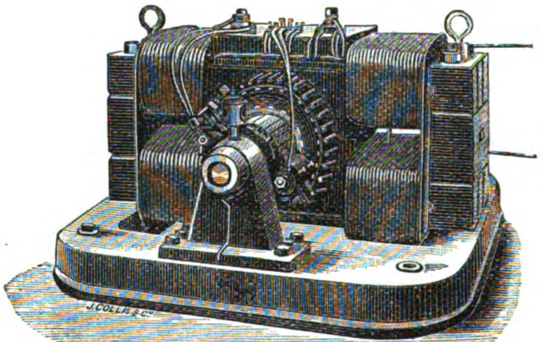

FIG. 16.
Horizontal Phœnix Dynamo, supplying 600 60-watt Lamps.

shows a dynamo constructed for fourteen arc lamps in series, each lamp requiring 50 volts and a current of from 8 to 10 amperes. It is intended to run at 1,000 revolutions per minute. Similar machines to this are in use for lighting the Covent Garden Theatre. The type is followed with machines up to 1,000 volts. Fig. 14 shows a vertical Phœnix dynamo of the pattern designed for ship lighting to be driven by belts or ropes. The dynamo, as will be seen, is mounted on a cast-iron bed plate, and is fitted with a screw-tightening gear. The speed is 1,000 revolutions, giving an E.M.F. of 110 volts and a current of 150 amperes, intended to supply 250 60-watt lamps. Fig. 15 shows a horizontal machine in-

tended to run at 1,150 revolutions, and to give 75 amperes at 110 volts, supplying 125 60-watt lamps. Machines of this type are made to supply from 100 to 300 lamps. Fig. 16 is also a horizontal type machine,

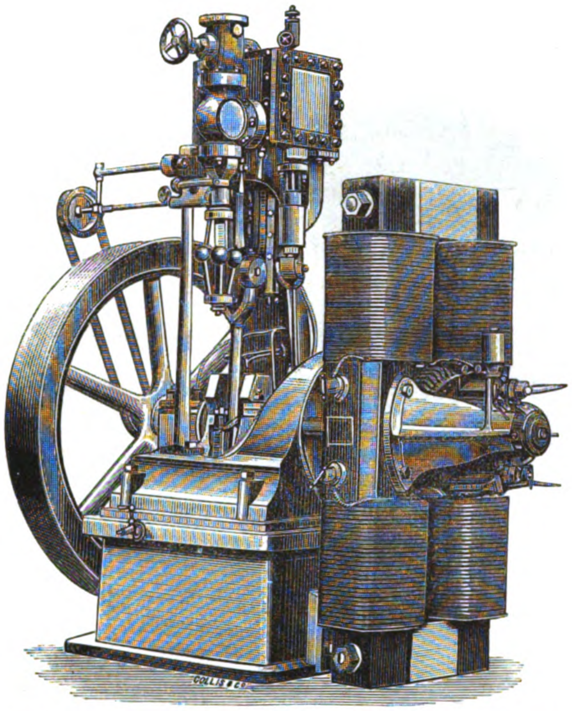

Fig. 17.—Ship Lighting Phœnix Dynamo, Driven Direct.

to give, at 650 revolutions, 360 amperes at 110 volts, and is intended to supply current to 600 60-watt lamps. Fig. 17

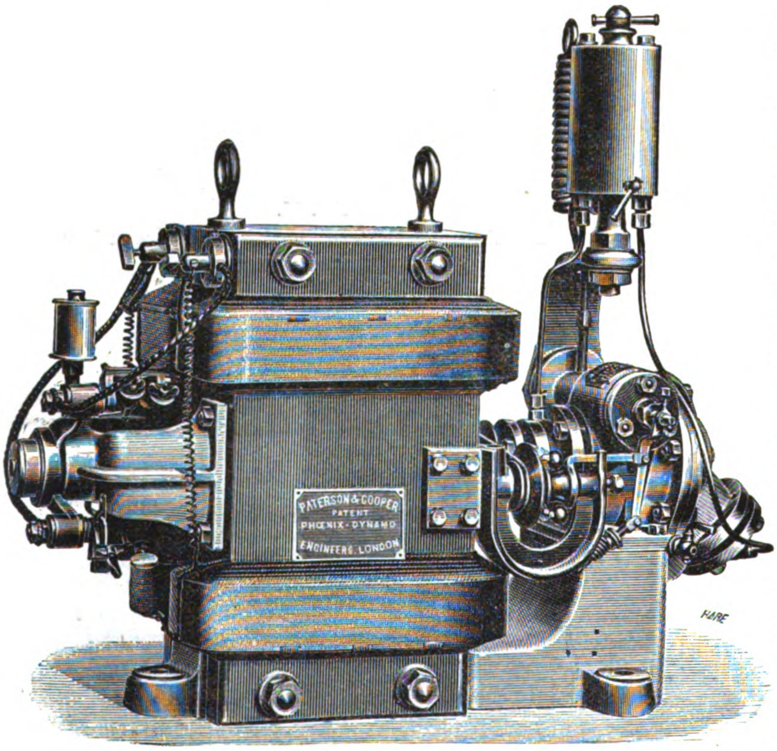

Fig. 18.—Phœnix Machine for Torpedo Boats.

illustrates a ship lighting direct-driven machine, coupled to a Gwynne engine, with a speed of 400 revolutions, supplying 100 60-watt lamps, with a current of 60 amperes, at an E.M.F. of 110 volts. Fig. 18 is a machine designed for torpedo boat lighting, coupled direct to a tower engine. It is made in two sizes, No. 1 size running at 750 revolutions, giving 50 amperes at 80 volts. The last machine made by this firm (shown in Fig. 19 below), is a small machine designed for arc lighting, and is intended to give current for one or two arc lamps requiring 8 to 10 amperes of current at 100 volts. The speed is 1,600 revolutions per minute. A similar class of machine is made for incandescent lighting.

Messrs. Ganz and Co., of Budapest, construct a direct current four-pole dynamo, possessing several features of interest. The machine is compound-wound, and may be termed

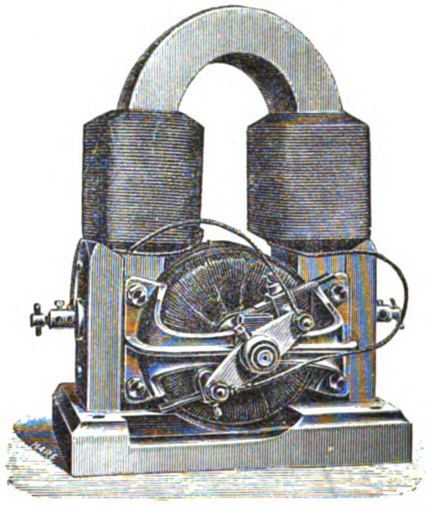

Fig. 19.—Paterson and Cooper's Small Dynamo, for Arc or Incandescent Lighting.

a 50-unit machine, the output being given as 50,400 watts, with an E.M.F. of 105 volts at the terminals, at 670 revolutions per minute. The horse-power required at the normal speed for the above output is given at 75·5, and the commercial efficiency 91 per cent., the electrical efficiency being 95·8 per cent. The compounding is intended to provide a constant potential at the end of a main in which 5 per cent. is lost when the full load is reached. The size of this machine over all is 1,440mm. by 1,285mm. by 780mm., and its weight 2,500kgs., *i.e.*, about $2\frac{1}{2}$ tons. The weight of iron magnetised is 1,500 kgs., or about 3,150lb.; that of copper is 240 kgs., or about 520lb. These figures give 20 watts per kilogramme of machine, or, say, 10 watts per lb. of whole weight, and 210 watts per kilogramme of total copper, say 100 watts per lb. of copper. The cores of the field-magnets are of wrought iron, the bedplates and pole-pieces of cast iron, the weight of the magnet cores being 560kgs., and the sectional area of the pole-pieces 920 sq. cm. The following details are given us with respect to the winding of the series and the shunt coils:—Firstly, as to the series coils: 4 coils are placed near the pole-pieces of the lateral magnets. In every coil four wires are wound parallel. One end of every coil is connected to one of the four brush holders, and two and two of them to the terminals of the machine. The length of the wire in each coil is 12·15cm., the diameter 6mm. Sectional area of wires through which whole main current passes 226 sq. mm., and the resistance 0·00215 ohm measured after machine had been running at full load for several hours. Amperes per coil 240, turns in each coil 15, turns for each magnetic circuit 15, ampere turns for each magnetic circuit 360, total ampere turns in series coils 14,400. Loss 495 watts, and current density 2·13 per sq. mm. Secondly, coming to the shunt coils,

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we have two coils on the middle magnets, with 10 layers of 70 turns; four coils on the lateral magnets, with 10 layers of 68 turns. The whole six coils are connected in series and to the terminals of the machine. The length of wire on the middle magnets together is 1,540m., on the lateral magnets together 2,200m. The diameter of all wire is 2·4mm., and the sectional area is 4·5 square mm., resistance, as connected, 16 ohms after several hours run. Amperes 6·56, turns on middle magnets together 1,400, on lateral 2,720, ampere-turns on each middle magnet 4,590, and on lateral 4,450. Ampere-turns for each magnetic circuit 9,040. Total turns on the six magnets 4,120. Total ampere-turns on the six magnets 26,980. Watts lost 695. Current density 1·46 amperes per square mm. Taking the total coils, the ampere-turns for each magnetic circuit are 9,500, the total ampere-turns 41,380, and the watts lost 1,185

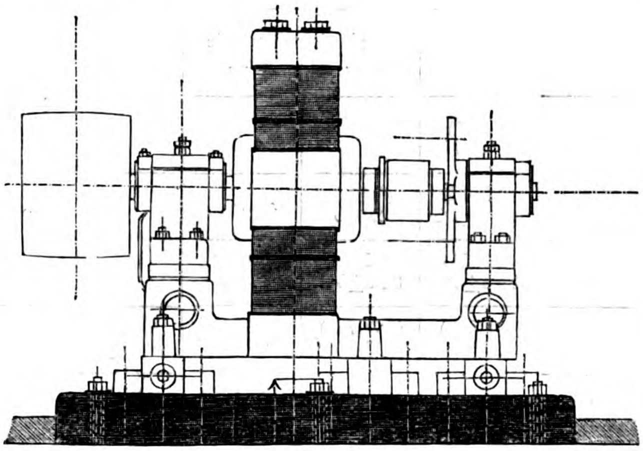

Fig. 20.

The armature is of the toothed drum type, built up of varnished sheets, with an axial length of 300mm., and a diameter of 420mm. The diameter of the field space is 433mm., the air space between teeth of armature and pole-pieces being

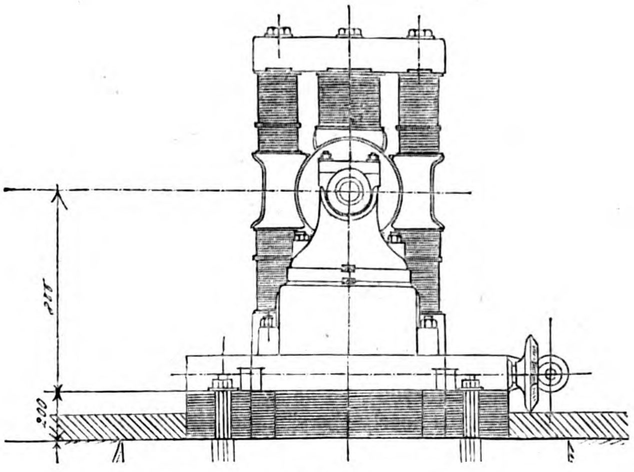

Fig. 21.

6 5mm. Number of teeth and channels 48, breadth of channel 13mm., depth 28mm.; number of wires in each channel 8, of diameter 5mm.; number of circuits between brushes 2. The total length of wire composing twenty-four turns is 29m., and total weight of wire used in winding in the armature 41kgs., including connections 50kgs. Sectional area of wire, 19·6 square mm. Watts lost in armature and connections to commutator, 995. Weight of iron in armature without axle, 190kgs. Watts per kg. of copper 1,008, *i.e.*, about 450 watts per lb. of wire. Volts per metre of wire, 3·73. Strength of magnetic field in armature, 17,900 C.-G.-S. units, or 19·5 lines of force calculated according to Kapp's formula. Strength of magnetic field on the boundary of the pole-pieces 5,480 C.-G.-S. units. The mechanical details show that the lengths of bearings are respectively 276 and 240mm.; diameter, pulley 550mm., breadth 400mm.; number of brushes, 4 pairs; number of bars in commutator, 48.

We think the electrical world will agree with us, that the figures kindly supplied by Messrs. Ganz and Co. are among the most complete and most interesting that have ever been given concerning any dynamo. Figs. 20 and 21 give two views of this machine, and further illustrations will be given in another issue.

(To be continued.)

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the late meeting of the British Association on various subjects connected with Electrolysis :—

ON THE CONDUCTIVITY OF MIXTURES OF AQUEOUS ACID SOLUTIONS.

BY DR. SVANTE ARRHENIUS, OF STOCKHOLM.

An abstract of a paper to appear in Wiedemann's *Annalen*, specially made by the author, and communicated through Oliver Lodge. The translation made by W. N. Shaw.

1. *Methods employed and previous authors.*—Hitherto only comparatively few experiments on the conductivity of mixtures of electrolytes have been made by Bouchotte,* Paalzow,† Bender,‡ and Klein§. These experiments have, moreover, led to no definite general results, mainly on account of the paucity of experimental data.

My experiments have been made at 25° C. in the chemical laboratory of the Polytechnic at Riga on Kohlrausch's well-known method, with the use of the telephone.

2. *Distribution of the water among solutions.*—When two electrolytes are dissolved in the same water two different views of the nature of the solution may be held: either *all* the water affects the one electrolyte as well as the other, or the water divides itself so that one part of it only affects the one electrolyte and only the remainder the other electrolyte. Experiments (by Ostwald) have been made with acetic acid and butyric acid. Normal solutions of these acids have conductivities respectively of 1·478 and 1·020. According to the second view the conductivity of the mixture will be $\frac{1}{2}$ (1·478 + 1·020). It was found to be 1·250 (instead of 1·249). According to the first view the mixture would have a conductivity equal to the sum of the conductivities of acetic acid of half normal strength (1·119), and of butyric acid of half the normal strength (0·853); this would give the conductivity of the mixture 1·972. Many such experiments were arranged, and all showed the superiority of the second view. All the experiments discussed in this paper also prove the soundness of this view. We shall consequently adopt this second view in what follows.

3. *Fundamental formula.*—If two electrolytes (in dilute aqueous solution) are mixed in the proportion of $m:n$, and if the conductivity of the one solution be a, and that of the other b, then the conductivity of the mixture will be $\frac{ma+nb}{m+n}$ if the solutions suffer no change in the mixing. This formula is the mathematical expression of the idea that the conductivity depends solely upon the number of electrolytic (active)

* *C.R.* tome LXII. p. 955, 1864.
† Poggendorff's *Annalen*, Bd. CXXXVI. p. 489, 1869.
‡ Wiedemann's *Annalen der Physik und Chemie*, Bd. XXII. p. 197, 1884.
§ *Inaug. Diss.* Würsburg, 1885.

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molecules per unit volume and on the friction of the ions in the solvent. This friction undergoes no appreciable change in dilute solutions.

4. *Consequences of the interchange of water in the mixture of solutions.*—When hydrochloric acid solution is diluted the number of electrolytic molecules increases but very little* (for the sake of simplicity we may assume that the number does not increase at all). When, however, a solution of acetic acid is diluted the number of electrolytic molecules is considerably increased (*e.g.*, by dilution to twice the volume from a normal solution the increase is in the ratio of 1·51 : 1). When, therefore, solutions of hydrochloric acid and acetic acid are mixed the conductivity will be greater than the above formula shows if water is transferred from the hydrochloric acid to the acetic acid solution, and *vice versâ*. In general when solutions of a stronger and a weaker acid are mixed, and the weaker acid takes water from the stronger, the conductivity will be greater than that given by the formula, and conversely if the stronger acid takes the water of solution from the weaker. A formula for this phenomenon is easily deduced; it shows that if the above consideration is valid the conductivities of the original solutions must not be very widely different; it likewise shows that the greatest deviations from the formula occur when the solutions are mixed in equal quantities.

5. *Isohydric solutions.*—If a given solution of an acid be mixed in equal volumes with solutions of another (stronger) acid of different degrees of concentration it is found that the above formula is applicable for a certain degree of concentration. For greater concentration negative deviations will be found, and on the other hand for less concentration positive deviations. According to the explanation given above, that solution of the second stronger acid, which possesses the particular degree of concentration, is of such a nature that it neither takes away water from the first solution nor gives any up to it when the two are mixed. On this ground I call in what follows two such solutions of different acids relatively *isohydric.* I have defined the concentrations of the solutions by their conductivities.

The experimental method for the determination of the conductivity of isohydric solutions will be most easily explained by means of an example.

To find the hydrochloric acid solution, which is isohydric with tartaric acid (75·51).† Under "observed" is placed the conductivity found, under "calculated," the conductivity calculated by the formula given.

	Obs.	Cal.	Diff.
5 cc. tartaric acid solution (75·51) + 5 cc. hydrochloric solution (94·62)	84·49 ...	85·07 ...	− 0·58
5 cc. tartaric acid solution + 5 cc. hydrochloric acid solution (85·68)	81·34 ...	80·60 ...	+ ·78

By interpolation (and allowing for the error of observation = 0·5 p.c.), we get as isohydric with the tartaric acid solution (75·51) the hydrochloric acid solution (89·2 ± 2·9). In a similar manner the numerical values contained in what follows have been obtained.

6. *Examination of the view adopted in* § 2.—This examination was conducted in two different ways: (*a*) *Solutions which are found to be isohydric when mixed in equal volumes must also be isohydric when they are mixed in other proportions.*

This proved to be the case. Phosphoric acid (223·7) and hydrochloric acid (167·4) were mixed in the ratios 3 : 1, 2 : 2, and 1 : 3; oxalic acid (4·947) and acetic acid (4·837) in the ratios 10 : 3, 1 : 1, and 3 : 10; tartaric acid (1·566) and hydrochloric acid (1·757) in the ratios 10 : 3, 1 : 1, and 3 : 10; acetic acid (12·18) and hydrochloric acid (14·54) in the ratios 10 : 1, 10 : 2, 10 : 4, 10 : 7, 1 : 1, 2 : 3, 1 : 2, 1 : 5, and 1 : 10. In no case was there a difference between the observed and calculated conductivities which reached the limit of the error of observation (0·5 p.c.)

(*b*) *Solutions which are isohydric with any the same solution must also be isohydric with each other.* Otherwise, as is easily seen, we might have three solutions, among which a permanent current of water would circulate always in the same direction. I have found—

A. (*α*) Phosphoric acid (225·6) isohydric with oxalic acid (139·7 ± 7·5).
,, ,, ,, ,, ,, hydrchlric acid (168·8 ± 10).
(*β*) Oxalic acid (141·7) ,, ,, ,, ,, (166·4).
B. (*α*) Hydrochloric acid (88·59) ,, ,, tartaric acid (75·00 ± 2·5).
,, ,, ,, ,, ,, oxalic acid (85·07 ± 3·5).
(*β*) Tartaric acid (75·39) ,, ,, ,, ,, (82·08 ± 3·3).
C. (*α*) Formic acid (5·576) ,, ,, ,, ,, (4·901).
,, ,, ,, ,, ,, hydrochloric acid (5·309).
(*β*) Oxalic acid (4·915 ± 0·17) ,, ,, ,, ,, (5·336 ± 0·13).

It will be seen that the numbers are perfectly satisfactory.

7. *Table of isohydric solutions.*—In the following table particulars of isohydric solutions of six acids, as different as possible, are collected; their conductivities (multiplied by 10^8) are given, together with the possible errors. Above the conductivities I have put in brackets the number of gramme-molecules per litre of the corresponding solutions. These are calculated from Ostwald's numbers. Solutions more concentrated than normal ones have not been investigated.

Hydrochloric acid.	Oxalic acid.	Phosphoric acid.	Tartaric acid.	Formic acid.	Acetic acid.
(0·1737) 609 ± 35	(0·513) 607				
(0·0461) 168·8 ± 10·0	(0·0625) 139·7 ± 7·5	(0·337) 225·6			
(0·0238) 88·6 ± 2·9	(0·0031) 85·1 ± 3·5	(0·0764) 82·2 ± 8·2	(0·520) 75·0		
(0·00475) 17·98 ± 0·46	(0·00488) 16·27 ± 0·46	(0·00702) 16·11 ± 0·72	(0·0260) 16·41 ± 0·45	(0·1077) 16·85 ± 0·64	(1·000) 13·81
(0·001402) 5·336 ± 0·134	(0·00135) 4·915 ± 0·175	(0·00163) 4·926 ± 0·174	(0·00324) 4·903 ± 0·146	(0·01261) 5·467 (± 0·15)	(0·0965) 4·855
(0·000349) 1·524 ± 0·032	(0·000396) 1·582 (± 0·05)	(0·000440) 1·479 ± 0·057	(0·000498) 1·499 ± 0·20		(0·009175) 1·476

8. Since obviously any solution of two acids in the same water can always be represented as two isohydric solutions, it follows that *when two acid solutions are mixed the two acids divide themselves with reference to the water, so that two isohydric solutions are formed.*

From the above table it follows that the specific conductivities of isohydric solutions are approximately equal.

Further considerations, which cannot here be given, show that if the conductivity of a mixture of acids is calculated on the assumption that solutions of equal conductivity are isohydric, the probable error amounts to 1 p.c., being rather greater if the strengths of the acids are very different, and less if they are nearly equal.

9. *Supplementary Remarks.*—The different bases have also been examined in a perfectly similar manner. The results obtained are strictly analogous, including the equality of the conductivities of isohydric solutions. However, the carbonic acid of the air had produced a disturbing effect to such an extent that the numbers are too uncertain for publication. I have also found that acetic acid (1·166) is isohydric with ammonium acetate (0·469). The ratio of the conductivities of the two (2·485 : 1) is nearly the same as the ratio of the maximum values of the conductivities of acids and salts (2·83 : 1 according to Kohlrausch). This seems to point to the conclusion that an electrolytic or active molecule of an acid (at ordinary temperature) in water conducts 2·83 times as well as an electrolytic molecule of a salt, and not that in extreme dilution the acids are, say, more loosely combined ("disgregirt") than the salts. This arises probably from a smaller friction of the ion H of the acid (probably also of the O H of the bases) with respect to the water, in which it also occurs as an ion, than occurs with the other ions. This difference might disappear at higher temperatures.

From the hypothesis that the different electrolytes divide the water between them there arise relations which promise to

* *i.e.* the molecular conductivity increases—I refer always here to dilute solutions.

† By this is understood tartaric acid of conductivity 75·51. The units here employed may be reduced to Kohlrausch's by multiplication by 10^{-8}.

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explain some very curious phenomena. If, for example, a weak acid or base and a neutral salt are dissolved in water isohydric solutions will be found, in which the weak acid or base will get extremely little water. In consequence, its molecular conductivity, and accordingly the number of active molecules, will be very considerably diminished. I anticipated this on other grounds in my paper of 1884,* and endeavoured in that way to explain that the weak acids prove to be much weaker on mixing with bases than they are for the same concentration when no other bodies are in the same solution. The same hypothesis may also explain the great depreciation of strength of weak acids when neutral salts are present, as calculated from the rapidity of reactions,† and of the weaker bases in saponification reactions. I am still engaged upon the solution of similar questions.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

ADDRESS OF THE PRESIDENT, SIR CHARLES BRIGHT.

In addressing you at the first meeting of our new session, I wish in the first place to express my most cordial thanks for the honour conferred upon me in being elected to the office of President during the present year, the more so because it is a period specially interesting to us, as in it occurs the Jubilee of the Accession of our beloved Sovereign, and also of the first practical realisation of the electric telegraph. I am glad to be able to state that our society continues to flourish; and to maintain its justly acquired reputation for the value and utility of the papers read, and of the discussions upon them, which are often of more importance than even the papers themselves, as bringing forward views and information on diffe ent sides of the questions raised; and, while I refer to this, I wish to say that I should like to hear more, if possible, during the discussions in the course of this session from those who have not been so long in the society as some of us, and the only way to obtain this result is that those who join in the early part of any discussion should make their remarks as concise and as much to the point as possible, so that our juniors may have time left to speak. The total number of our members of all classes is now 1,343. At the first meeting, in February, 1872, it was only 110. At that meeting the President, referring to the *raison d'être* of the society, adverted to the impossibility of one great scientific body like the Royal Society succeeding in cultivating all the different departments of science in detail; and that therefore other societies, like the Astronomical, the Geological, the Chemical, or our own, were essential for their own especial fields of scientific knowledge and practice.

It is somewhat curious that Dr. Priestly had the same views when, so long as one hundred and twenty years ago, in the preface to his "History of Electricity," he suggested that an Electrical Society should be formed, to be devoted to electrical and kindred investigations. "The business of philosophy," he said, "is so multiplied that all the books of general philosophical transactions cannot be purchased by many persons or read by any person. It is high time to subdivide the business, that every man may have an opportunity of seeing everything that relates to his own favourite pursuit, and all the various branches of philosophy would find their account in this amicable separation. Let the youngest daughter of the sciences set the example to the rest, and show that she thinks herself considerable enough to make her appearance in the world without the company of her sisters." This suggestion of Dr. Priestly, made in the year 1767—long before galvanism, electro-magnetism, thermo-electricity, and magneto-electricity were known—bore no fruit, at all events not for many years. In June, 1837, however, a society was formed entitled the "London Electrical Society," of which Mr. Gassiot and Mr. Sturgeon were the principal founders, one becoming, subsequently, the treasurer, the other the first president. The name of the former will be well remembered for his researches in electricity, and for the liberal manner in which he constructed apparatus on a large scale for the purpose. The latter name suggests a long record of experiments, of which the most valuable was his discovery of magnetising bars of soft iron and rapidly changing their polarity by voltaic currents; in other words, the invention of soft iron electro-magnets, which are so largely used in telegraphs, telephones, and almost every kind of electrical appliance.‡

Mr. Sturgeon, the president of that society, in his inaugural address in October, 1837, claimed that "electricity was the most important experimental science ever cultivated by man," and remarked that the "preceding forty years had been more productive of electrical discovery than all the antecedent centuries embraced in the history of the science."§ Sturgeon was justified in his conclusion; for those forty years included the labours and discoveries of Volta, Brewster, Arago, Humboldt, Wollaston, Davy, Œrsted, Ampère, Schweigger, Ohm, Becquerel, and, above all, of Faraday, who was then in the midst of his ever memorable experiments. A number of papers, upon almost every branch of electrical science then known, were contributed to the *Proceedings* of the London Electrical Society, part of which were published in its *Transactions*, which will be found in our library, and the remainder in Sturgeon's "Annals of Electricity." The society however, lacked in vitality; there were in its best days only 76 members, and it was finally dissolved in a little less than six years. The late Mr. C. V. Walker, who was one of its members, having joined in April, 1838, told us, in his presidential address here, all about the decline and fall of that small society. He ultimately became both treasurer and secretary. As treasurer, in the culminating year of decay, he only received £77 with which to pay himself as secretary, for the printing and publishing of the *Proceedings* and all other expenses of the society. Now, our Society of Telegraph-Engineers and Electricians commenced its yearly accounts at the end of 1872, with subscriptions to the amount of £422. In *its* sixth year the treasurer received £1,275, of which £615 was expended in printing and issuing the society's valuable *Journal*. The income last year amounted to £1,818. The income of the society was, during the first years of its existence, almost exclusively derived, as it still is, to a very large extent, from the subscriptions of those who are more or less intimately associated with electric telegraphs, for although every other branch of applied electrical science is now well represented on the list of members, a large contingent of subscriptions still come from those engaged in the Postal Telegraphs, in the Indian Government Telegraphs, in the large submarine cable companies, and, in fact, from telegraphists spread over the face of the globe; others, again, from the large manufactories connected with the supply of telegraphic instruments, materials, cables, and their accessories. Our society might well use the motto of the Royal Engineer, "*Ubique*", or, let us say, "*Quæ regio in terris nostri non plena laboris.*"

A purely electrical society might perhaps have had more success than its predecessor, at the time when our society was established, but I doubt it; for, on investigating the practical applications of electricity for the general use of mankind during the last half century, we find that nearly the whole of the work done and capital invested has been connected with electric telegraphs, at all events until 1878, since when a material movement has taken place in the development of electric lighting and telephones. The earlier part of the present century was one of surpassing interest in the advance of electrical knowledge, and all the requirements for an electric telegraph were at hand: the voltaic battery, the electro magnet, the multiplying coil, the magnetic needle, together with the knowledge that, if suspended, it could be deflected by a galvanic current passing through a fixed coil adjacent to it; all were ready, and it is not to be wondered at that numerous devices for carrying on telegraphic communication by means of electricity were proposed and shown by many philosophers and experimentalists in different parts of the civilised world. Ampère himself proposed, on the suggestion of the illustrious La Place,* that a telegraph might be made with needles deflected in such a manner as to communicate different letters of the alphabet; and it was subsequently computed, at the trial of an American patent case, that more than sixty claims might be made out for suggestions of various kinds for an electric telegraph prior to its actual realisation. It is no part of my purpose to attempt to award the proportion of merit due to each or any of the long array of inventors. Hundreds of most promising discoveries have died an early death for lack of industry or perseverance to foster them. The man who begins by inventing, and afterwards struggles through every obstacle and with the greatest difficulty brings it into actual practice, outstrips, to my mind, him who is merely the *projector* of even the most ingenious invention which history records. A man of genius and perseverance, such as I have pictured, thus expressed himself some years later upon the subject:—"It the electric telegraph were to be described generally in a few words, how should it be described? Might it not be called an application of a few known principles by means of a few simple contrivances to produce a practical result, which the experiments of scientific men, although their attention had been directed to the subject for a long series of years, had failed to produce? The merits of the invention must therefore consist, to a very great degree at least, in the practical realisation of that which before had been an idea or an experiment."† The writer of the foregoing was Mr., afterwards Sir William, Cooke, an officer in the Madras Army, who returned from India on furlough in 1831. The Liverpool and Manchester Railway had been opened for public traffic a few months before, and had proved a great success, the receipts being what was then considered the enormous sum of £250 a day, or a little more than £90,000 per annum. This was derived from fares of 7s. 6d., and three trains running each way daily. The public were fully appreciative of the boundless advantages of this stupendous power, and the general interest in it was almost without parallel. Notions of speed and distance were still relative, but their meaning had been changed. New railways were announced from London to Birmingham, thence to Manchester, and in many other directions. Cooke was a man of great intelligence and scientific tastes, and the effect on the history of telegraphs produced by the interest which this altered state of locomotion awakened in his mind will be seen hereafter. A few years later, viz., in March, 1836, when at Heidelberg, he saw for the first time, at the lecture room of the professor of Natural Philosophy, one of those experiments to which I have referred as being frequently exhibited to illustrate the possibility of telegraphing to a distance by electricity; it was fitted up between the professor's study and the lecture room, and consisted of a pair of suspended needles and fixed coils much after the fashion of Ampère's idea suggested by La Place fifteen years before, which had, however, like many others, been unproductive of any useful result. Cooke was deeply impressed by this experiment, and with the conviction that electricity might be applied as an instantaneous means of communication for the working of the railway system then extending all

* "La Conductibilité Galvanique des Électrolytes," Partie II., p. 77.
† Spohr, *Journ. f. prakt. Chem.* [2], XXXII., p. 32.
‡ *Transactions*, Society of Arts, Vol. XLIII., 1825.
§ "Annals of Electricity," Vol. II., p. 61.

* *Annales de Chimie*, I. XV., p. 72.
† See "Cooke's Comments on De Hamel's book," p. 70.

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over England, as well as for Governmental and general purposes. So sanguine was he as to the success of his scheme that he at once abandoned his former pursuits and devoted himself exclusively to the practical realisation of an electric telegraph. Within three weeks he made his first telegraph, besides working out numerous supplementary details. In November, 1836, he showed to Mr. Faraday the apparatus which he had constructed in order to exhibit to the directors of the Liverpool and Manchester line. No grass had grown under his feet since the idea had flashed on his mind some months before at Heidelberg. He was still absorbed in the first notion which struck him, of associating his electric telegraph with the working of railways for their mutual "safety and economy."* Early in the next year he became acquainted with Prof. Wheatstone, who had been in the habit of showing, in his lecture room, the feasibility of telegraphing by electricity, using two galvanometers and a permutating keyboard, by which deflections of the magnetic needles could be exhibited.

There is no occasion here, or in any civilised country, to descant upon the great scientific attainments and achievements of Sir Charles Wheatstone, from his memorable experimental determination of the velocity of electricity, in 1834, to the remarkable recording telegraph apparatus perfected by him in later days with the skilful aid of our ingenious mechanical engineer, Mr. Stroh, a member of our council. The result of the two experiments becoming known to each other was that they soon after agreed to combine their inventions. A patent in their joint names was applied for, receiving the great seal on the 12th June, 1837. The specification of this, the first patent for electric telegraphs in any country, is very elaborately drawn up, occupying forty-six large printed pages and three large sets of drawings, showing the details of their inventions. It comprises a complete reciprocal telegraphic system, indicating instruments of several kinds, sending and receiving keys very much like some of those used even now, methods of supporting and insulating the conducting wires, alarums worked by relays, and means of ascertaining faults in the line-wire by the use of detectors. The wires were to be placed in troughs, being previously covered with cotton and a resinous cement, and with varnish of different colours for the several wires, so as to distinguish them in case of repairs being needed. It will be seen by the foregoing abstract, and still more by any one who will examine this highly interesting specification, that the joint patentees had considered in a most careful manner many of the requisites and contingencies of the work which they were about to undertake. I may add that in after years the validity of the patent was upheld in two cases of infringement. Soon after the patent was granted permission was given by the directors of the London and Birmingham Railway to lay down the wires between Euston-square and Camden Town Station; and by the latter part of July, 1837, the first practical realisation of the electric telegraph in its application to railway working was ready for trial. Late in the evening of the 25th of that month Mr. Cooke and Prof. Wheatstone stationed themselves—the one at Camden Town Station, the other at Euston-square. In order to try whether the instruments would work through considerable distances, some miles of wire along which the current had to pass (besides the wires in the open air) were suspended in the large carriage-house near the Euston-square terminus, making the length 19 miles. Several friends of the inventors were present at Camden Town, among others, Mr. Brunel and Mr. Stephenson. Prof. Wheatstone first spelt out a message, and, on Mr. Cooke quickly and clearly answering from Camden Town, the practical realisation was accomplished. "Never did I feel such a tumultuous sensation before," said the Professor, "as, when all alone in the still room, I heard the needles click, and as I spelled the words I felt all the magnitude of the invention now proved to be practical beyond cavil or dispute."† I myself well remember experiencing feelings somewhat akin to those of the Professor some 28 years ago, when on board the "Agamemnon," steaming slowly into Valentia Bay, finishing the laying of a telegraph cable two thousand miles long, which extended to Trinity Bay, Newfoundland, the greater part being under water two miles in depth. The apparatus used on that ever memorable occasion at Euston and Camden Town was the diamond-shaped dial instrument, with vertical needles on horizontal axes, described in the specification and shown in the drawings. The instrument required five wires, and it may be asked why should instruments like this have been employed when they had others needing but one? The reason was that the former called for no skill in sending and receiving the messages, each letter being expressed by a simple signal of two of the needles converging to a letter. With this the inventors could easily telegraph to each other, and railway *employés* could take up the work after them without any delay; but I doubt if either Cooke or Wheatstone could have spared the time at that period to become proficient in sending or receiving a telegraphic *code*. The wires, which were laid up in a rope and placed in a trough, did not cost much in the manner they were made, though good enough for the time and the short distance. Moreover, the battery power required was small, and its action in deflecting the vertical needles to one or the other side was very simple and certain.

Thenceforward the electric telegraph prospered without a check. Wires were laid down on the London and Blackwall, and on the Great Western line between Paddington and Slough, and elsewhere. At first it was used only for railway purposes, but afterwards despatches were transmitted for the public at 1s. a message (without reference to length), which was the first popular use of the telegraph in England or any other country. Its application soon became nearly as miscellaneous as now, affecting the highest and lowest in the land—now acquainting the Queen that Prince Albert was leaving Paddington for Windsor, now effecting the capture of thieves going down for business on an "Eton Montem Day." At one time sending the Queen's speech at Westminster for the benefit of the Royal borough, at another ordering whitebait from London, or inquiring about luggage left behind. All at once the country was awakened to the importance of this new means of communication by the result of the following message from Slough to London:—"A murder has just been committed at Salthill, and the suspected murderer was seen to take a first class ticket for London by the train which left at 7:42 p.m. He is in the garb of a Quaker, with a brown greatcoat on, which reaches nearly to his feet. He is in the last compartment of the second first-class carriage." A little difficulty arose in transmitting this message, for in the signals of the instruments v answered for u, and there was no q, so the word "Quaker" was spelt K W A K E R, which the operator at Paddington did not at first comprehend. However, the delay was not enough to prevent proper arrangements being made for Tawell's reception. On arriving at the Paddington Station, after mixing with the crowd for a short time, he got into an omnibus, the conductor of which was a policeman in plain clothes. Tawell, the Quaker, no doubt thought, as one passenger got in and another was put down, that his identity was getting better mixed each time. At last, reaching the Bank, he got out, paid his fare, and after crossing and recrossing London Bridge, and making many turns and doubles, he went to a lodging house in Scott's-yard, Cannon-street. He had scarcely entered the hall when the omnibus conductor opened the door, and asked him, "Havn't you just come from Slough?" "No," said he. He was of course arrested at once, and afterwards tried, found guilty, and executed. The effect of Tawell's capture was a greatly increased demand for the telegraph and a great extension of the system. Cooke, who, in his deed of partnership with Wheatstone in 1837, had reserved to himself the exclusive management of the invention and the sole control of the engineering department, found his labours prodigiously increased. To use the words of one who was with him at the time: "With his own eye and his own hand he directed all the operations in the actual erection of the first telegraphs; he literally lived, for the time being, upon the railway, making a railway carriage his shelter by day and his couch by night."* He still held fast to his original plan of allying the telegraph with the railway, which afforded a wayleave, protection, and speedy access for repair in case of defect in the wires; while the safety and efficiency, as well as economy in the working of the railway were supplied by the telegraph by signalling every train from station to station and telegraphing generally throughout the line concerning engines and rolling stock. In a book issued by him in 1842, entitled, "Telegraphic Railways," I was startled to find the following:—"To illustrate the practical working of these arrangements under extraordinary circumstances, I will now follow an *express*, and *therefore unexpected*, train in its course from Derby to Leicester." He then proceeds to describe the process of signalling it through its course. I have examined a "Bradshaw's Railway Companion" of the time and do not find any express, but only mail and ordinary trains. I think that an *extra* train was meant, for I find the expression used in the examination of Mr. Saunders, the Secretary of the Great Western Railway, on the 6th February, 1840, before a Parliamentary Committee† (among the members of which were Sir Robert Peel, Sir James Graham, Lord Stanley, and Mr. Labouchere, afterwards Lord Taunton). Mr. Saunders stated, in reply to Lord Granville Somerset, that the danger of collision in sending out an *extra* train, without a great interval of time being allowed between it and the ordinary trains, might be guarded against by the use of the telegraph. He also said, in reply to a previous question, that "it perfectly performs all the duty that was expected of it;" and, in reply to another question, "that it would simplify the working and diminish the stock of every description, whether of engines or carriages, besides ensuring greater punctuality; and, in cases of accident, to repair the injury with the least delay."

By the latter part of 1845 the double and single needle instruments were used everywhere, and the extent and ramifications of the telegraph had so enlarged that the time was ripe for connecting together the whole system, and forming a company for the general transmission of messages and news for the public throughout England and part of Scotland. In this part of the original scheme, Mr. Cooke was fortunate enough to obtain the co-operation of Mr. John Lewis Ricardo, M.P. for Stoke-upon-Trent and chairman of the North Staffordshire Railway, through the introduction of Mr. Bidder, who was then the engineer of the London and Blackwall Railway and other lines. Mr. Ricardo was a man of extraordinary sagacity and great energy. He became, and continued for many years to be, the chairman of the new corporation, which was styled the "Electric Telegraph Company." An Act of Parliament for incorporating the company was applied for in the Session of 1846. By this time, however, there were other competitors in the field. Mr. Edward Davy had taken out a patent in July, 1838, for a telegraph in which three wires were used, and metallic points attached to magnetic needles were caused to press upon, and so to make various groups of marks upon chemically prepared calico at the receiving end, the solution employed being hydriodate of potash and chloride of lime. The patent was bought by the Electric Telegraph Company, but never came into use. Other patents were also taken out in 1841, 1843, and 1845, for a type-printing, an indicating, and an electro-chemical copying telegraph, by Mr. Alexander Bain, of Edinburgh, a most fertile and ingenious inventor, who had previously devised an electric clock. Another type-printing machine was also patented at the end of 1845, as a communication from Mr. Royal E. House, of the United States, by Mr. Jacob Brett, of which his brother wrote, in 1858, that this instrument "incurred a sacrifice on my part of many thousand pounds, without any valuable result for general purposes."‡

The Electric Telegraph Company found on going to Parliament that

* "Telegraphic Railways." By W. F. Cooke.

† *Quarterly Review*, No. CLXXXIX. p. 125.

* "Telegraph Manipulation." By C. V. Walker.

† *Fifth Report of the Parliamentary Committee on Railways*, and *Mech. Mag.*, Vol. XXXIII., 1840, p. 168.

‡ "Origin and Progress of Oceanic Telegraphs." By J. W. Brett.

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they were opposed by Mr. Bain, who declared in his petition that he had invented an electric printing telegraph, and had previously communicated his invention to Prof. Wheatstone. When it came to the Lords' Committee, the Duke of Beaufort, its chairman, told the company's counsel that they had better arrange with Mr. Bain, hinting rather plainly that their Bill might otherwise be thrown out. A compromise was accordingly arranged; the company got their Bill, and Bain got £12,000. His patents were transferred to the company, and he entered into an obligation to give the company the use of any further inventions. He was subsequently elected a director of the company. Bain's prolific genius was soon at work again, and in December, 1846, he patented his electro-chemical telegraph, which consisted of a train of clockwork at each end of the line. At the sending station a paper ribbon, about half-an-inch wide, perforated with holes representing the different letters of the alphabet, as required for the message to be sent, was drawn over a conducting cylinder in connection with the earth and under a metallic spring or style connected to a battery, the other pole of which was connected to the line wire. At the receiving station a paper ribbon, moistened with an acidulated solution of ferro-prussiate of potash, was in like manner drawn by the clockwork over a metallic cylinder connected to the earth, and under a metallic style connected to the line wire. The clockwork being set in motion, which was done by a current causing an electro-magnet to act upon a detent, the current passed through the circuit making a blue mark at the receiving end whenever the sending style passed over a perforation and came in contact with the cylinder, and leaving a corresponding blank when the sending style passed over the non-conducting paper between the perforations. The instruments worked with wonderful rapidity; the blue marks appearing to stream out from the recording style as if by magic, so that a number of operators were employed to each instrument to make the perforations in the sending paper, which was done by mechanism causing it to pass between rollers and under a punch—one hole formed a "dot," and three a "dash," of the Morse alphabet. An experiment was tried in Paris with this electro-chemical telegraph before M. Leverrier and Dr. Lardner, in which a message of 282 words was transmitted through a continuous wire 1,082 miles in length, consisting of two telegraph wires joined together at Lille, making 336 miles, and 746 miles of insulated silk-covered wires in coils. "A pen," says Dr. Lardner, "attached to the other end, immediately began to write the message on paper moved under it by a simple mechanism, and the entire message was written in full in the presence of the committee (each word being spelled completely and without abridgment) in fifty-two seconds, being at the average rate of five words and four-tenths per second. By this instrument, therefore, it is practicable to transmit intelligence to a distance of upwards of 1,000 miles, at the rate of 19,500 words per hour."* I myself often saw, in the year 1847, Bain's telegraph working at an astonishing speed between Manchester and London, and have never been able to understand the cause of its being abandoned. The only inconvenience was the occasional breakage of the damp paper when handled by the operator; but this was obviated later on by Bain having a disc of prepared paper, like a large filter paper, placed on a metallic plate of the same size, which revolved round its centre, the style having a slow motion from the centre to the edge of the disc, so that it described a spiral commencing at the centre and terminating at the edge.† In this way there was no occasion for the writer of the message to touch the paper. It will at once be seen that Bain's telegraph was the father of the beautiful and rapid automatic instrument of Sir C. Wheatstone and Mr. Stroh now used at the Post Office, the latest speed of working which, as I am informed by Mr. Preece, is 435 words per minute, or 115 words faster than Leverrier and Lardner's experiment with Bain's telegraph. This speed of more than 70 distinct currents passing through the line wire and the instrument in a single second of time calls to mind Juliet's

"Lightning, which doth cease to be
'Ere one can say it lightens."

Nevertheless, having regard to the amazing number of currents generated in a second by the armature of a dynamo-electric machine, running at a high speed, I could not say that the limit has been by any means reached with the automatic telegraph.

Let us now return to the Electric Telegraph Company after they had come to terms with Bain and obtained their Act of Incorporation. Foreseeing the possible and, indeed, the probable contingency of other telegraphs being brought forward, they set to work, under Ricardo's guidance, to convert Cooke's contracts with the railway companies from wayleaves into exclusive agreements for a long term, so as to keep any other telegraph from passing over the line. This sagacious policy was successfully carried out, especially in the case of the leading railways and those comprising the great trunk lines from London to the north and west. By their Act they had the power to lay pipes and wires under the streets of towns, and by the 1st January, 1848, the company opened offices for receiving and transmitting public messages in London, Birmingham, Manchester, Liverpool, and other important places, which could also communicate with the many smaller places and railway stations previously connected up. The only large towns not in communication with the central station in Lothbury were then Bath, Exeter, Plymouth, Brighton, Chatham, Oxford, and Preston.‡ The charges were, however, much too high. A message from London to Birmingham or Stafford cost $3\frac{9}{10}$d. per word; to Liverpool, Leeds, or Manchester $5\frac{1}{10}$d.; York, $5\frac{3}{4}$d.; Edinburgh, $7\frac{1}{2}$d.; Glasgow, $8\frac{3}{4}$d.; Derby, Norwich, Nottingham, or Yarmouth, $4\frac{1}{2}$d. Even a lawyer, under the influence of such a tariff, became suddenly endowed with a power of writing on any subject in a most laconic style, which in his office he would have conscientiously declared to be positively impossible. The progress of the Electric Telegraph Company was gradual, but never flagged. In 1850 it had 1,786 miles of line and 7,206 miles of wire; in 1860, 6,541 miles of line and 32,787 miles of wire, with 3,352 instruments; and in round figures, when Government contracted to purchase the telegraphs in 1868, 1,300 telegraph stations in Great Britain and Ireland, 10,000 miles of line, 50,000 miles of telegraphic wire, 8,000 sets of instruments, 3,000 skilled persons in its employ; three Continental cables under its control.*

The year 1850 was notable in the history of the company, because, owing to its high tariffs, a clamour arose for competition, and in that year Acts of Parliament were granted to the Magnetic Telegraph Company and to the British Electric Telegraph Company, which afterwards amalgamated under the name of the "British and Irish Magnetic Telegraph Company," generally known as the "Magnetic Company." I was engineer to the latter company; Mr. Edwin Clark at the time, and afterwards Mr. Latimer Clark, and following him Mr. Culley, filling the office of engineer to the Electric Company. My brother, Mr. Edward Bright, was manager, and in later years also engineer, of the Magnetic Company from its commencement to the Government purchase in 1870. Such of the railways in Great Britain as had not been exclusively secured by the Electric Company were eagerly arranged for by the new company, and nearly all in Ireland, which had not been then thought worth attention by the Electric Company. In this way competing lines were established on the Lancashire and Yorkshire, East Lancashire, Leeds Northern, Newcastle and Carlisle, Glasgow and South Western, and throughout Ireland. To connect up with London, the Magnetic Company laid a line of ten wires in troughs, along the high road by Birmingham to Manchester, continuing six wires to Preston, Carlisle, Dumfries, and Glasgow, with a fork from Dumfries to Portpatrick, for reasons which I shall soon give. On the other side of the Irish Channel another underground line was carried from Donaghadee to Belfast and Dublin, and an isolated branch from Cork to Queenstown. These underground wires were of No. 16 gauge copper, insulated by a continuous coating of gutta percha. This remarkable substance, which becomes soft and plastic when placed in hot water and capable of being moulded, hardening again on becoming cool, was first introduced to this country by Dr. Montgomerie, of the Indian Medical Service, who, observing that the Malays used it for making basins, jugs, shoes, and knife handles, inferred, from the crude native manufacture, that extensive uses would be found for it in Europe. He therefore purchased a quantity and sent it in 1843 to the Society of Arts in London. Its value was speedily recognised; many patents were taken out for its manufacture, and its applications soon became too numerous to catalogue. What concerns us is its qualities of being a good insulator of electricity, insoluble under water, capable of being laid over a wire by being passed through a die when hot, yet being pliable and to a certain extent hard when cold. Dr. Werner Siemens was probably the first (viz., in 1847) to use it for covering wires laid underground, but a further use of world-wide importance was soon to be found for it. Gutta percha covered wires came into use in the tunnel wires on railways in 1847, and soon after for the wires laid in iron pipes under the streets of towns. In January, 1849, Mr. C. V. Walker laid a length of two miles of No. 16 gauge copper wire, coated with gutta percha, in the English Channel, from the sands near the Pavilion Hotel at Folkestone, where the end was connected to the 83 miles of telegraph erected along the South Eastern Railway to London. The experiment was quite successful, messages being interchanged between the chairman of the company in London and Mr. Walker, on board the steamer "Princess Clementine," at sea, with the end of the gutta percha covered wire on board.† A plan had been previously matured by Prof. Wheatstone, as long before as 1840, for laying a submarine wire, covered with rope, between Dover and Calais, of which full particulars were given by Mr. Sabine in our *Proceedings*; but nothing came of it, and it was not until 1850 that the first telegraph message was sent across the Channel.‡ The late Mr. John Watkins Brett, to whom I have referred before in connection with House's type-printing telegraph, has justly been generally credited with the merit of having first taken this enterprise seriously in hand. So early as 1845, he was imbued with the conviction of a submarine telegraph being a possibility, and with his brother, Mr. Jacob Brett, registered on the 16th June in that year, a company for uniting Europe and America by submarine communication. He did not know of Prof. Wheatstone's channel project, concerning which he afterwards said: "Had these facts then been known to me, I cannot say how far they might have damped my determination to devote my whole time and means to establish and promote the submarine telegraph, and, if possible, to bring this country into instantaneous communication with India and America, then the sole object of my thoughts."§ An "oceanic line" was also included in his brother's patent for the printing instrument,‖ in which the wires were to be "coated with various colours to distinguish them." After obtaining permission from King Louis Philippe¶ in 1847, to unite England with France by a submarine cable, followed by a concession from Louis Napoleon, when President of the French Republic in 1849, a single copper wire, covered with gutta percha to the diameter of half an inch, was laid on August 28th, 1850, from Dover to Cape Grisnez, the greatest depth passed over being 30 fathoms. At every sixteenth part of a mile a leaden clamp or weight was securely fastened on to secure it in position. Messages were interchanged between the steamer "Goliath" and the English shore while the wire (which was coiled on a large drum) was being

* "Museum of Science and Art," Vol. III., p. 117.
† *North British Review*, XLIV., p. 559.
‡ *Mech. Mag.*, Vol. XLVIII., p. 44.

* "Government and the Telegraphs." Effingham Wilson. 1868.
† "Electric Telegraph Manipulation," p. 102, Walker.
‡ *Journal* of the Society of Telegraph-Engineers, Vol. V., p. 90.
§ *Proceedings* Royal Institution, March 20, 1857.
‖ No. 11,010 of 1845.
¶ "Origin and Progress of the Electric Telegraph," p. 63, J. W. Brett.

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laid, and afterwards between the two shores. Next morning, however, the circuit was broken, and it was found that the action of the waves had rubbed the wire upon the rocks, and destroyed the coating of gutta percha.

(To be continued.)

THE SELF-INDUCTION AND RESISTANCE OF COMPOUND CONDUCTORS.

BY LORD RAYLEIGH, D.C.L.

(Continued from page 172).

In view of the statement* "that the coefficient of mutual induction is less in iron than in copper wires," I may mention an experiment made with the aid of one of the compensators, in which the effect of the substitution of iron for copper is directly examined. The mutual induction measured is that between two circuits, one of which was composed of the two copper coils of 21 and 22 convolutions spoken of above connected in series; and the other of a single turn of wire situated midway between, and lying in a shallow scratch or groove on the wooden cylinder, by which its position was accurately defined. The arrangements being the same as in the determination of the constant of the compensator, the value of the double induction (obtained by reversal) between the circuit of a single turn of copper wire and the circuit of 43 turns was 40°·7. The single turn of copper wire was now replaced by a turn of iron wire of equal diameter and bedded in the same scratch, with the result that the double induction was 40°·6, the same value being obtained whether the iron wire were included in the primary circuit with the battery and interrupter, or in the secondary with the telephone. Care had, of course, to be exercised in the disposition of the leads, in consequence of the use of a single turn only for one of the circuits. So far as the experiment could show, the induction is absolutely the same, whether the single turn be of iron or of copper.

To return now to the bridge arrangement, the following are a few examples of the use of the original form of apparatus. The scale of the wire readings was in $\frac{1}{50}$ inch, the whole length (Q+R+S) being 1960. In ohms the resistance of the whole wire is 4·00. The interrupter was the "reed," making about 1050 (complete) vibrations per second. Thus

$$p = 2\pi \times 1050.$$

The first case is that of a helix of insulated copper wire, without core of any kind. To get a balance the compensator had to be placed at 54°, so that M = 36°, each degree representing 776 centim. The resistances also necessary were

$$Q = 610, \quad R = 190; \quad \text{therefore } S = 1160:$$

They are expressed in scale divisions, the value of each of which is

$$\frac{4{\cdot}00 \times 10^9}{1960} = 2{\cdot}04 \times 10^6 \frac{\text{centim.}}{\text{sec.}}.$$

If, as we are almost entitled to do, we assume that the resistance P to variable currents is the same as that readily found with use of steady currents, viz., 87·3 scale divisions, we may at once deduce

$$L = M\,\frac{P+Q+R+S}{S} = \frac{36 \times 776 \times 2833}{1160} = 68200 \text{ centim.}$$

We will, however, dispense with this assumption. Eliminating L between the two equations, we get for the determination of P,

$$P\left\{1 + \frac{p^2M^2}{S^2}\right\} = \frac{Q\,.\,R}{S}\left\{1 - \frac{p^2M^2(Q+R+S)}{S\,.\,Q\,.\,R}\right\}.$$

In the fractions containing M^2 the resistances must be expressed in absolute measure. We find

$$\frac{p^2M^1}{S^2} = \frac{4\pi^2 \times 1050^2 \times 36^2 \times 776^2}{1160^2 \times 10^{12} \times 2{\cdot}04^2} = {\cdot}0061;$$

$$\frac{p^2M^2\,(Q+R+S)}{S\,.\,Q\,.\,R} = \frac{4\pi^2 \times 1050^2 \times 36^2 \times 776^2 \times 1960}{1160 \times 610 \times 190 \times 10^{12} \times 2{\cdot}04^2} = {\cdot}1189;$$

so that

$$P = {\cdot}876\,\frac{Q\,.\,R}{S},$$

differing some 12 per cent. from the value (QR/S) given by the usual formula. Inserting the values of Q, R, S, we have

$$P = 87{\cdot}5 \text{ scale-divisions.}$$

This is the effective resistance to variable currents of the frequency in question.

With steady currents the readings were

$$Q = 557, \quad R = 190, \quad S = 1213;$$

so that

$$P_0 = \frac{557 \times 190}{1213} = 87{\cdot}3.$$

The resistance to variable currents, calculated by the correct formulæ with knowledge of the frequency of vibration, is thus almost identical with the value found with steady currents; whereas if we were to ignore the disturbance of the ordinary resistance rule by induction, we should erroneously conclude that the resistance to variable currents was some 12 per cent. higher than to steady currents.

Of other experiments made with this coil I will only mention one. When a stout copper rod was inserted, the circumferential secondary currents induced in it altered the readings with variable currents to

$$Q = 660, \ R = 190; \ M = 29\tfrac{1}{2}°.$$

The effective self-induction is evidently diminished, and the effective resistance increased in accordance with the universal rule*. The precise values may be obtained from our two fundamental equations, in the manner exemplified above.

If the foregoing experiment (with the copper core) be attempted with the scraping-contact interrupter, giving a mixed sound, no definite balance is obtainable.

The second example that I shall give is of a wire of soft iron about 1½ metre long and 3·3 millim. diameter. Here with variable currents from the reed-interrupter, of the same period as before,

$$Q = 178, \ R = 190, \ S = 1592; \ M = 8 \times 776 \text{ centim.};$$

from which we find

$$P = {\cdot}985\,\frac{Q\,.\,R}{S} = 20{\cdot}93 \text{ scale divisions.}$$

In the present case the ordinary simple rule (QR/S) would lead to an error of 1½ per cent. only.

The resistance to steady currents is given by

$$P_0 = \frac{100 \times 190}{1670} = 11{\cdot}38.$$

We may conclude that the effective resistance to variable currents of this frequency (1050) is 1·84 times the resistance to steady currents.

A long length of wire from the same hank was examined later by another method, and gave for the ratio in question 1·89.

In some of his experiments † Prof. Hughes found that it made but little difference to the self-induction of an iron wire, whether it was arranged as a compact coil of several turns, or as a single wide loop. The question is really examined with the present form of apparatus; for, since the resistance is not altered, the compensator readings give an accurate relative measure of the self-induction. A hank of nineteen convolutions of insulated soft iron wire required for balance 25°·8; but when opened out into a single (approximately circular) loop, the reading was only 11°·2, a much greater difference than that mentioned by Hughes.

A better experiment may be made with a coil of doubled wire. The length previously used was divided into halves, which were tied together closely with cotton thread and bent into a compact coil of 9 convolutions and about 4½in. diameter. When the two wires were connected in series, in such a manner that the direction of electric circulation was the same in both, the self-induction was represented by 24°·2; but when one wire was reversed, the self-induction fell to 9°·2, the

* *Proc.* Roy. Soc., Vol. XL. p. 468.

* See equations (8), (10), (11), (12), *Phil. Mag.* May 1886, pp. 373—375.

† *Proc.* Roy. Soc., Vol. XL p. 457.

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large difference depending entirely upon the mutual induction between the two iron wires.

I had intended to apply this apparatus to investigate the self-induction of wires of various materials and diameters, formed into single circular loops, but the subject has been so ably treated by Prof. Weber as to render further work unnecessary, at least as regards the non-magnetic metals.

That the circle is the proper standard form for accurate measurement cannot be doubted; but the effect of magnetic quality is shown most markedly when the wires compared are of given length and diameter, and doubled so as to form single close loops. For a total length of $2l$ of copper wire, the self-induction is smallest when the wires are just in contact, and then*

$$L = 3{\cdot}772\, l.$$

In practice some interval is required for insulation, so that the coefficient of l may perhaps be taken to be 4. To iron wires the theory is not strictly applicable,† but we may probably assume without serious error

$$L = l\,(4 \log 2 + \mu) = l\,(2{\cdot}772 + \mu),$$

μ being the *permeability*. Prof. Hughes finds for the ratio of iron to copper under these circumstances 440 : 18‡; according to which we should have

$$\frac{3+\mu}{4} = \frac{40}{18},$$

or $\mu = 95$, in approximate agreement with values found by other methods.

Although the original apparatus of Hughes is capable of very good results, and is especially suitable when the wires under test are in but short lengths, the fact that induction and resistance are mixed up in the measurements is a decided drawback, if it be only because the readings require for their interpretation calculations not readily made upon the spot. The more obvious arrangement is one in which both the induction and resistance of the branch containing the subject under examination are in every case brought up to the given totals necessary for a balance. To carry this out conveniently we require to be able to add self-induction without altering resistance, and resistance without altering self-induction, and both in a measurable degree. The first demand is easily met. If we include in the circuit the *two* coils of an induction-compensator, connected in series, the self-induction of the whole can be varied in a known manner by rotating the smaller coil. For the self-induction of the instrument, used in this manner, may be regarded as made up of the constant self-inductions of the component coils taken separately, and of twice the positive or negative mutual induction between them. The first part, in consequence of its constancy, need not be regarded; and thus every degree (within the admissible range) may be taken as representing $2 \times 776{\cdot}3$, or 1552·6cm., of self-induction.

The introduction, or removal, of resistance without alteration of self-induction cannot well be carried out with rigour. But in most cases the object can be sufficiently attained with the aid of a resistance-slide of thin German-silver wire. It may be in the form of a nearly close loop, the parallel out-going and return parts being separated by a thin lath of wood. A spring of stout brass wire making contact with both parts short-circuits a greater or less length of the bight.

(To be continued.)

ELECTRIC STREET CARS.

In our issue of December 24th we gave an important paper upon this subject, which was read on the 7th ult. by Mr. Martin before the American Institute of Electrical Engineers. At the close of the paper the following discussion took place, which will be found to contain statements of considerable interest:—

Mr. J. Murray Mitchell: I rise for the purpose of corroborating what Mr. Martin has said in relation to the Baltimore road, and also to direct your attention, and I think, perhaps, also his, to the fact that in the comparison shown in his report between horse-power and electricity, the comparison of $6.50 to $4 is not as advantageous to electricity as it should be, because the average speed which is accomplished there with electricity is eight miles an hour, and the speed which they formerly had was only four miles an hour, which of course reduces the cost in comparison, so that the cost of electricity should be put at about $2, as against $6.50, instead of $4, as against $6.50.

Mr. J. Wetzler: Mr. Martin has remarked in his paper that one of the principal points to be considered was the coal bill. It is interesting, therefore, to note that in the Julien electric railway at Hamburg a calculation has recently been made on the basis of sixteen hundred kilometres run; that is equivalent to about one thousand miles. Mr. Huber, the engineer there, calculates that for one thousand miles run the energy required to propel the car one kilometre was, on the average, equal to three-fourths of a horse-power hour. Now, that figures out in this way—If it takes three-quarters of a horse-power an hour to propel a car one kilometre, and assuming that three pounds of coal per horse-power per hour is what a fair, average engine will do, then the energy or coal required to propel the car one mile would be three and a half pounds of coal per car mile. Now, take for instance, the Third-avenue road in New York. On a basis of three and a half pounds of coal required to propel a car a mile, we should have, assuming there were three hundred cars—I think Mr. Martin puts it at 360—say, then, there are sixty extra cars, which are either summer cars, or cars laid off for repairs, that would give 175 pounds of coal per car per day. I am basing that figure on a run of fifty miles per car per day. That would give 52,500 pounds of coal a day, or twenty-six and a quarter tons. Calculating a ton at three dollars, we should have for the coal bill alone per day only $78.75, and that is with accumulators. I think the company would be very willing to spend $78 for coal, if that will do it. That is what it figures out at.

The Chairman then called upon M. Julien, who spoke in French, his remarks being translated by Mr. C. O. Mailloux.

M. Julien said that the circumstances under which the tests were made at Antwerp were such that they represented almost an inimical feeling to the question of electrical traction by any process whatever. During the six months that the tests lasted every detail of the system was subjected to the closest scrutiny; the cells were sealed, and they were kept almost under lock and key, and he was scarcely allowed himself to look at them. The tests were made by judges, the most competent engineers and electricians, and were made with every precaution that might be necessary to prevent any tampering with the regular order of procedure. Referring to the statement made by Mr. Martin, and the assertion based on it made by Mr. Wetzler, that the expenditure of energy necessary for electrical traction is three-fourths of a horse-power hour per kilometre, and that as the energy required for the lamps must also be counted in, which he certainly thought would be ten cents a day, he calculated that the total expense of about two dollars a day per car would be necessary for the energy actually needed, and that counting an expense of two additional dollars for all other costs of maintenance, wear and tear, interest and various other expenditures, that we would arrive at the cost of four dollars which had been mentioned. M. Julien said that the cost was thus found by the experiments made at Antwerp, and that cost might be considered, so to speak, historical; that it might be conceded to be the cost on which they could safely calculate the probable expenditure of running the electrical car, with accumulators, on heavy traffic.

Mr. C. J. Van Depoele: I can simply corroborate what has been said. Still, there is one little plant that I might give the exact cost of, because the cost is about the main thing to be considered. We ran a plant in Minneapolis, Minn. This is, I believe, the largest electric railroad ever run in this country, or anywhere else, so far as I know. We have there about a sixty horse-power motor, and the train consists very often of ninety tons weight, or ninety-one tons. We have run it for about nine months. I might state also that they have tried a soda motor there, which I will tell about later. But at all events we have been running there at about an expense of 3,000lb. of coal a day—that is, starting to work at six o'clock and running till half-past eleven at night. Certainly, any of the locomotives that used to do the work before consumed as much as four tons of coal a day for the same work, which shows that although we have to transform our power twice, still we will have a great economy over the ordinary steam engine. Our system is not now running, for the simple reason that some other parties persuaded the authorities there that they were going to bring there for them to use something wonderful in the shape of a soda motor—a soda fountain with a stick in it, or something of that kind. The soda motors came, and we went off the track and let them on. But let me say those soda motors can hardly pull themselves, and at present are lying there like a lot of old scrap iron in the shops of the railroad. Of course the authorities there would not at the present time like to take back the electric motors for fear of stultifying themselves. But we ran very practically over the route, using only very common apparatus. The whole thing was only a common freight car with four ordinary 36in. wheels and an ordinary gearing from the motor to the countershaft and from the countershaft to the axle of the wheels and to the axles of the common car, wearing out only one belt in all that time and working eighteen hours a day, carrying forty-seven of their regular railroad trains a day. So it was shown that electricity can be used for heavy work as well as for light work.

Another instance in which figures might be given—of course all this figuring will come much easier after we have big plants running—is this: We are now putting up a big plant in Montgomery, Ala., where we have twelve cars running, and when all is finished we will be able to give the exact cost of running; but so far as we have tried it, and the grades are 6½ and 8 per cent. there—in fact, there is not a foot of level ground in Montgomery—with two cars we have consumed an average of nineteen

* Maxwell's "Electricity and Magnetism," §§ 686, 688.
† *Phil. Mag.*, May, 1886, p. 383.
‡ *Loc. cit.*, p. 457.

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hundred pounds of coal a day, so that it cost but five and a half or six dollars a day with the two cars with the engineers' wages. This is a very small plant, and if small plants can do as well as that, larger plants can do much better.

Mr. C. O. MAILLOUX: There is a question which is now agitating the minds of practical engineers, and which gives me the opportunity to ask Mr. Van Depoele a question. It is this: There is a great deal of doubt, a great deal of difference of opinion, as to the manner in which the energy shall be applied to the shaft of the motive wheel—the driving wheels. I heard Mr. Van Depoele say that he gears his motor to a countershaft and that he conveys the motive power from that countershaft to the driving wheel by means of a link belt. Now that link belt is, I understand some to say, one of the bugbears of the electric railway, and I would like to ask Mr. Van Depoele about the length of time that that link belt has been running; also about how great a velocity it will stand safely. That is to say, how many feet per minute will it run without making too much noise or without being strained unduly; and, also, how long the link belt will last under those conditions?

Mr. VAN DEPOELE: I will be very glad to answer this question. We have some link belts running now for the last eight or nine months on street cars. We have tried several different modes of transmission to gear directly to the axle of the car, something which will obviate the vibrations transmitted by the axles running directly over the road. There at once we have a flexible connection between the motor and the car. The motor can stand on the same body of the car itself and consequently does not participate in the heavy vibration to which it would be subjected if it were carried directly by the axles of the wheels. Consequently, with street cars that is about the best connection I can find at present. I would have it understood, however, that any ordinary link belting in the market will not answer the purpose. We have a link belt which we had made for the purpose of our business. We have tried the cast iron link belt and found it to make considerable noise, and to wear out too fast, while it is not capable of running at a high speed. I have run at thirty miles an hour, and I did not myself formerly believe that a link belt could do the work, but it seems that when it is solid and correctly made you can run it at that speed without hurting it. The link belt used by us consists of two side pieces of steel pressed, and the steel bushing pieces are then fastened to a steel thimble at the upper end. Right through that steel thimble goes a pin, which catches the two lower ends of the next link, and consequently there is no friction in the small parts, it being confined to the larger surface of the thimble, right over which there is a steel roller. There is really no wear to the chain. We have had in Windsor, Canada, a chain running there for about eight months, and, in fact, it is just as good to-day as when first put down. The belt was then running at about the rate, I should judge, of one-third less than what the wheels were, or fully twenty miles an hour; and at the end of the track I stopped to feel whether the belt was hot, and it was not warm at all. Of course, for heavy work and fast speed, I think the link belt would not be suitable. Then you want to have a direct mode of connecting. Certainly it is very difficult to get a good connection between the motor and the axles of the wheels, because to make a motor large enough to connect directly with the axles of the wheels without any gearing, the motor has to be made too large. I think it would be out of the question to so construct it for ordinary speeds. But to gear back, of course, you have to use some kind of gearing. Friction gear I do not take much stock in. It is not reliable; it wears out, and there is always some trouble about it. Of course the cog-gear is positive, but it makes too much noise. But if you put up gear that is solid and mathematically true and with good lubrication I find there is not much noise when the gear is entirely covered up. We have the same gear in Scranton, which cannot be heard when running. It is well boxed and works well, and does not wear out and fits tightly, although how long it will last of course we do not know. We have several of them running, and they run well. If you gear back in the ratio of one to eight you will have a good deal of noise, at one to four you will hardly have any noise at all, at one to eight there will be considerable wear, at one to ten, of course, still more. There is a kind of medium between those, and you will have to take your choice in making your proportions; but the link belt, I believe, is the best thing for street cars to-day—that is, a belt made specially for the purpose.

Mr. G. W. MANSFIELD: I certainly would strengthen Mr. Van Depoele's remark that it is a most difficult and exceedingly troublesome thing to find any good method of connection between the motor and the driving wheels. He has spoken of a variety of methods of doing it, and there are other varieties yet of which he has not spoken. But one thing which he said, viz., that the link belt gave a flexible connection between the motor and the driving shaft, is an excellent plan, and, in fact, it would be necessary where you needed a flexible connection. But I would like to bring up just this one point, and that is that we have before us two distinct fields to labour in. One field is to equip the 20,000 cars already in this country, running over some three or four thousand miles of track and being drawn by some 125,000 horses, and with the system of construction which now prevails; and the street railroad men, of all men, I believe, are hunting not only for a means of propelling their cars, but they are also hunting for a better means and better mode of constructing their railroads. Now, with the present variety of construction of a large majority of the street railroads of this country you would need your flexible connection and possibly leather belts, perhaps the link belts; or possibly a good combination of gear can be arrived at to get this flexible connection. But the other field is the field of new construction, and this field is the one in which, I think, the electricians should specially labour. They should start now, and not wait five or ten years, but should educate the railroad profession and the street railroad men and the street railroad builders—the street car builders, rather —convincing them that their cars and that the street railroads must be built for electric motors. And if then they are built for the electric motors, we can supply them with something which is perfection, which will entirely do away with a great many evils which exist with horses and with every other means of drawing and propelling the cars, even with the cable. The cable has a limited field; it cannot operate branches successfully, and it has a variety of other evils which I will not speak of now. But with the electric methods in the construction of new roads, due to the marvellous flexibility of electrical application, there is no known or conceivable difficulty that electric motors and the application of electricity cannot successfully eradicate and overcome. So, then, I would merely give expression to this simple, modest thought, which the electric railroad men and the profession engaged in that work should impress upon the minds of all street railroad men, and all men interested in street railroads, viz., that their roads in future must be constructed from the very start for the application of electric motors, no matter by what system, but by the application of electricity. Then, I think, and by that means only, will we come to the general and successful application of the motors to every railroad throughout the country. It was at the meeting of the Electrical Section of the American Institute, that I gave an illustration, by means of diagrams, of the different kinds of methods which had been used, as far as I was familiar with them. I can only now repeat, if you desire, just those methods which I presented then, but I do not wish to discuss the efficacy of any single one of them. I said then that the most primal and the most perfect method obviously would be the application of the armature to the driving shaft direct. That does away with every particle of gearing. That method has been utilised by Mr. Daft in regard to a certain system more especially, and that is the Enos elevated system. The motor locomotive has two driving wheels and the armature shafts extend on each side of the driving wheels, the armatures being keyed directly on the shafts, and, of course, the periphery of the driving wheel is small. It is figured for a certain speed, twelve to fifteen miles an hour. The main difficulty which, I think, exists in using this direct gearing is simply a constructional one, on the electrical basis. The ordinary horse car wheel, if I remember rightly, goes only some ten or a dozen revolutions a minute to accomplish the ordinary speed which is used upon the tramways. Now, then, to construct a motor or an armature to go at that slow rate of revolution and develop any power, you would have to go to just the extreme which Mr. Van Depoele mentions and thus construct a *pretty* large motor. If you go into the electrical portion of it, you will see that you have got to get a certain length of wire upon your armature to get counter electromotive force and to do that at such a low rate of speed you have to construct a *rather* large machine, I think. Now, then, there is, next, a simple pinion upon the armature shaft, which runs in a large gear and is keyed upon the driving shaft. That method is simple, but it has its objections, although, if the mechanical details are properly carried out and well proportioned, even up to as high a ratio as eight to one or ten to one, I think that a very successful application can be made, and that is the application used on the Baltimore road. Worm gear can be used which is equally as simple as a pinion within a gear; it is equally as simple, but it is not as economical. The action of a worm in a gear is, we have always been told, a very brilliant method of losing power; that as high as thirty, forty, fifty, and even sixty per cent. of power is lost, due to the friction of the worm within the gear, although Mr. Reckenzaun, I believe, states that he has constructed a worm of a very high pitch, and has constructed his gear to match, and he gets a very low loss, 15 or 20 per cent., if I remember rightly, running in oil. Now, then, we go from that more simple process to another one, which is introducing one more subject, and that is a countershaft. Now, we can drive dynamos by a train of gears. We can drive from a pinion upon the armature shafts to a gear upon the countershaft, and then again from a small gear out of that upon a driving axle. Of course, any little difficulties which were apparent in the previous case would be increased in this case by the introduction of another gear. The noise could be cut down by using leather belting, and a variety of leather belts, round, flat, angular, and link belts. An innumerable number of forms of leather belting can be used which would take the rapid revolutions of the armature shaft and carry them to the countershaft with very little loss and with not much noise, and then the slower running countershaft with a pinion upon that, running the slow gear or slow driving axle, can then be employed very easily and with scarcely any noise and with very little wear. The flexibility, then, of this system would be between the armature shaft and the countershaft. Now, there can be a different modification of this, even, and I have noticed a description of one used by an inventor out West, in which he used a train of gears very similar to all the gears that are on the lathe in the ordinary machine shops. That is Prof. Henry's method, I believe. Now, that is the perfection of complication, and I do not know that I can go any further than to mention it in just this brief outline of the various ways which I am familiar with, that have been in practical operation. There is one other which I perhaps should mention in regard to a direct running with no intermediate gearing. I ought to have mentioned it first; it is that brought out by Mr. Stephen D. Field lately, and consists in using a crank shaft on the end of an armature shaft, which is attached to a connecting rod. That certainly does away with all intermediate gearing, and if he can successfully cut down the speed of the revolutions of his armatures to apply it to a street car, with all the street car difficulties of going so exceedingly slow as to keep pace with a mule that has two tons behind him and a very cross-grained disposition in front, and you have got to go just behind him and cannot go before him—if he can cut it down to that slow rate of speed, of course, for tramways, there could not be anything much better. But for lighter suburban roads, where you have got the right of way, and where you want to run at a rapid rate of speed, of course, then the direct application is superb.

Mr. S. D. FIELD: As to Mr. Mansfield's remarks, there are two ways to obtain the equivalent of speed of armature necessary. One is to confine

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yourself to the ordinary two-pole machine, using an excessive number of armature turns; the other is to increase the number of poles of the machine. This I have accomplished and with only two brushes. Then, again, with regard to the conduits for city traffics, I propose, in introducing a street railroad on a line already established, to take out the sleeper bodily and put in its place a hollow cast iron girder, the top of which is capped with a steel rail with a flange carried underneath, giving a slot with a sharp angle to the street surface, so that you cannot get a horse's heel calk into it, but you can have your carrier in there. Mr. Martin said that this was the only way to carry very high potentials. I propose to carry 1,000 volts or more, but at the same time have the minimum strain on the insulators; that is, the insulating medium. To accomplish that I establish a power station at either end of the line, have two conductors insulated, and carry a zinc potential in one conductor and a copper potential in the other. Now, every car on such a line has exactly the same potential wherever it may be. By that means I can carry as high as a thousand volts on the line with great ease, and you have got to have this high electromotive force with a large number of cars and reasonably sized conductors. There is no other way to do it that I can see. Then for very large motors I wish to call your attention to a little improvement. You know how the things will spark unreasonably. I find that the spark is not governed by anything particularly. It seems to vary with the load, and with the machine, and with the man that works it. I thought I would let the spark govern itself. I have put a couple of brushes on the commutator at points of nominally equal potential on either side and connected them with an auxiliary motor called the brush governor. As long as these brushes are at the proper point no current will pass into them. But let them get ever so little out, and immediately the current commences to go through the auxiliary motor, which turns the brush holder to position of neutrality. The result has been very satisfactory.

THE ELECTRIC TELEGRAPH.

A lecture was delivered on the above subject on the evening of the 7th inst. by Mr. Thomas Moy before a meeting of the Balloon Society of Great Britain, the chair being taken by Mr. Hyde Clarke.

On the motion of Mr. W. H. Le Fevre, C.E., seconded by Gen. F. Brine, a resolution was passed at the outset of the proceedings, expressing the sincere sympathy of the meeting with Lady Bolton at the death of Col. Sir Francis Bolton, C.E., a member of the society, and the founder of the Society of Telegraph-Engineers and Electricians.

Mr. Moy then delivered his lecture, in the course of which he said:— This is to be a Jubilee year. We are going to do all sorts of wonderful things to impart renown to 1887, and our newspaper editors and others will boastfully write about the enormous progress of science during the latter half of the present century. But it may be wholesome to moderate our estimate of progress. As far as my experience has gone, I have found that the people of this country are very slow in making real progress, and very boastful when a persevering inventor has pushed his invention through the mountain of prejudice usually standing in his way; and that a man of progressive mind, or a genuine inventor, gets a great many kicks when living, and a little posthumous praise when dead. When railways were in their infancy fifty years ago, I well remember the insane and ruinous opposition to their construction. When railways were pronounced a success, and John Bull's prejudice had been overcome, then came the jubilant fit. And what is our position to-day, scientifically and progressively? We have learnt how to utilise a few of the materials around us. We have learnt to weigh, calculate, and estimate what is likely to happen if we put this and that together; but as to what the materials really are we are as much in the dark as ever. Up to this time, this year of Jubilee, we are compelled to admit, as Newton did, that we are but as children playing with pebbles on the sea shore, while the whole ocean of discovery lies before us. We live in the midst of mysteries, and because they have become familiar to us we forget that they are still mysteries, and one of those familiar mysteries is electricity, which, as it becomes developed, becomes still more mysterious. What is this which we call the electric fluid, for want of a better name? If you think upon the subject you must wonder what it can be. We have found out various means of producing it, and have turned it to account in many ways, but without ever finding out what it is. The electric telegraph, with its various appliances, has grown, and is the result of the labours of many minds. We cannot say that So-and-so was *the* inventor. It did not burst upon the world as a complete discovery. Six hundred years before the Christian era it was observed that when amber was subjected to friction it acquired the power of attracting and repelling light substances. This is, perhaps, the earliest record in existence. The next record is that Theophrastus, 300 years later, observed that a hard stone (supposed to to be tourmaline), when rubbed, attracted light articles. Pliny, in the year 70, and others, noticed the same phenomenon. But none of these men appear to have possessed genius enough to follow up the inquiry, and it remained very obscure until Dr. Gilbert, towards the close of the sixteenth century, published in his work, "De Magnete," a list of all those bodies possessing the same property. Having traced the researches of subsequent investigators, he continued: Prof. Wheatstone worked at the subject from 1834, and in 1836 his acquaintance with William Fothergill Cooke commenced, followed by a partnership, the result of such partnership soon being made apparent by their jointly patenting, on the 12th day of June, 1837, the first really practical scheme in electric telegraphy. It is due to these men to say that fifty years ago they gathered up the facts that then existed, put them together in a practical form, added to them many valuable arrangements of their own, and thus presented to the world that which will ever make their names renowned. The patent was, of course, followed by others, the results of further experiments and discoveries; but the filing of their application on the 12th June, 1837—only eight days before Her Majesty's accession to the throne—marks this year, not only as the Jubilee year of Her Majesty's reign, but also as the Jubilee year of the practical application of the electric telegraph. You will bear in mind that I do not call Cooke and Wheatstone the inventors of the electric telegraph; but I do claim for them that they first established a telegraph for practical purposes on a large scale. After noticing the valuable discovery of Steinheil, and observing that at the end of this half century of telegraphy there was very little that Faraday did not forecast, Mr. Moy said: In the year 1853, that which had been considered impossible was actually accomplished. I refer to the methods of telegraphing in opposite directions at the same time in a single wire. An Austrian gentleman, Dr. Gintl, was the first to solve this problem. Frischen, Siemens, and Halske followed with improvements. This advance was followed in 1855 by another Austrian gentleman, named Stark, who invented and carried out a method of sending two messages along a single wire, in the same direction, at the same time. In estimating and describing the force of electric currents, I think that electricians have made a great mistake, and the sooner it is remedied the better. I refer to such words as amperes, ohms, volts, and other terms taken from men's names, as descriptive of the amount of electric force. Suppose, in describing a steam engine, we were to say the steam pressure in the boiler is 140 "Trevethicks," instead of pounds; the vacuum is 27 "Watts," instead of inches of mercury; the power is 2,000 "Stephensons," instead of horse-power. Could anything be more out of taste? And yet all the talented electricians follow this clumsy and illogical apology for scientific terms. Having thus very imperfectly dotted down something like a general outline of the progress of the science, we see that at a very early period in the history of the science the idea existed of using electricity for telegraphic purposes; but all proposals for effecting it were wanting in simplicity and practical contrivance until Messrs. Cooke and Wheatstone, having succeeded in their experiments, patented their ideas and placed them before the world 50 years ago, in 1837. Since that time the telegraph has been extended enormously, and we can now "wire" to almost the whole of the habitable globe. But on land there is something immediate to be looked after. The recent inconveniences arising from the breaking of telegraph wires show that we have erected them on the assumption that fine weather must prevail all the year round. That the wires will bear the strain put upon them by supports a great distance apart in fine dry weather has been amply proved; but that they will give way during a snowstorm has been also amply proved. The remedy therefore seems likely to be found in shorter lengths of stretch; in underground wires or in some new arrangement. Now, underground wires are expensive, and when a fault occurs it is troublesome to find its position; and other objections are urged. I would therefore throw out the hint that it is possible a middle course could be found in towns by suspending the wires at about, say 20ft. from the ground, with ornamental supports attached to the houses. The railway companies will also have to put up more numerous supports, or adopt the underground system. During the last 50 years many men of talent have come to the front with their ingenious inventions relating to electricity, and at the present time a whole army of intellectual men are working hard in order to increase the usefulness, cheapen the production, utilise the by-products, and discover new sources of electricity. After referring to the experiments in connection with the electric light, the lecturer said: Now, I think I must have exhausted your patience, if I have not the subject. We have been considering *one* of the mighty forces of nature, one of the invisible things of the Creator. We have, as it were, just touched the "fringe" of this force. We have glanced at the last 50 years of its practical application. What will the next 50 years bring forth in the further development of this power? Who would have dreamed 2,400 years ago, when the first piece of amber was rubbed, that that would lead to what we see to-day? Who can say that there are not other forces in the world, the existence of which is as yet undreamed of, which will be discovered in the next 50 years, and become absolute necessities to mankind? I think it will some day be discovered that gravitation is closely allied to electricity and magnetism, and, if I may venture to put the idea before you, it may be that the revolutions of the planets are analogous to the action of dynamos, and that the various fields and currents in which the planets revolve, and by which they are interlaced, may possibly produce that mysterious force which we call gravitation. When I contemplate the great forces of nature, and our utter ignorance of what they consist, I not only think of Sir Isaac Newton's celebrated saying, already quoted; but I go further than that, and ask myself, Are three score and ten years to be the limit of man's existence, and is there to be no future development of our powers, our knowledge, our investigations, our appreciation of real good? And the inevitable answer comes, trumpet-tongued, "No!" A thousand things contradict the possibility of such a result; for to quote again from another author, "God hath set eternity in man's heart," and nothing less can satisfy his reasonable aspirations. The lecturer resumed his seat amid applause, with which his remarks had been frequently greeted.

The Chairman then said he presumed he had been invited to preside as one of the few survivors of the old telegraphists of that period from which Mr. Moy had dated the jubilee. His own branch of investigation had been acoustic telegraphy, in which he followed Mr. Wheatstone, of whose early career he gave some account from actual knowledge. Mr. Wheatstone's preference was for acoustic telegraphy, and in the early period the electric system was looked upon as cumbrous and expensive, and one system exhibited in working at the Polytechnic Institution by Mr. Francis Whishaw was the hydrostatic. On Mr. Wheatstone engaging in electric telegraphy with Mr. Cooke, that plan was brought into practical effect, and there was an end of acoustic telegraphy and hydrostatic. They had to throw their old studies on one side and adhere to the acknowledged electric system. In science, however, what was

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really of value was never ultimately lost, and, if superseded by some other expedient, yet it might happen by that very expedient to be restored. Acoustic telegraphy being accounted dead, it was by the progress and development of the electric plan made more practicable, and under Graham Bell, Edison, Hughes, and others was brought into practical use in our days as the telephone. Francis Whishaw, the real originator of the great Exhibition of 1851, was obliged to enlist in the science of electric telegraphy. He (Mr. Clarke) was his colleague in making the final report on the electric telegraph for India, for the Hon. East India Company, and also on code arrangements for the Electric Telegraph Company here. The powers of the original costly apparatus were limited, and it appeared to be an object of primary importance to economise its use. Hence Mr. Whishaw was a great advocate of the code system as a means of transmitting more words with the same number of signals. On land lines the code is now of less value, on account of the rapidity gained by the duplex and multiplex telegraphy. On submarine systems, however, codes are extensively employed as a method for economising charges for messages. Whishaw was engaged at one time in adapting acoustic appliances for offices, particularly speaking tubes, and to one instrument he gave the name of telephone. At the early period described by Mr. Moy, the number of telegraph inventors here was very few; they could be counted, for there were few who had a definite idea of telegraphy, or looked upon it as a remunerative pursuit. His own appreciation of the value of such communicators was founded on the knowledge of the system of semaphores he had seen on the Continent, as established by Napoleon. That great administrator worked the semaphore from shore to shore throughout the bounds of his empire, and it was one of his great engines of government. It is, however, very difficult to prophecy as to the availability or impracticability of any matter of invention. Fifty years ago the number of inventors and investigators in this country was few; there was now probably an army of 5,000 inventors, investigators, and patentees in this country, and as many in the United States, each daily trying to get beyond the other. Hence, when any new discovery was made other applications extended or surpassed it. The effect economically was very remarkable, and likewise what was impracticable financially to-day was made feasible to-morrow. Those who remembered the experimental telegraph from Paddington to Slough which effected the arrest of Tawell, the Quaker murderer, would never forget how they were impressed by its rapidity of communication. A circumstance not less memorable was the rapid economy of cost. The first apparatus had a number of separate wires for signal letters, with an equal number of return wires. When the extension was projected it was considered these could be reduced to seven, with seven return wires. The seven were brought down to less; but during this time the earth circuit was found available and the return wires abolished. From three the wires were diminished to two. In the final result the number of wires and the cost were reduced to one-tenth. He himself remembered that while engaged on a submarine cable negotiation for Lisbon the cost of cables became reduced to a quarter, or from 100 to 25. In his own opinion, a great economy was yet to be effected in the cost of construction and laying of ocean cables. If invention and ingenuity effected great things, it was not always the inventor or the public who derived the benefit. In the case of that ingenious and able inventor, Alexander Bain, his patents were bought up by the Electric Telegraph Company at their own prices, and not used, in order to keep rival companies from employing them. If reward in a man's lifetime was by no means secure, still less certain was the poor heritage of posthumous fame, for which disappointed genius ever hoped. He hoped that the paper which had been read would be accepted in its proper light, as proposing a Jubilee, and that the Jubilee would be attended with practical results, and not be confined to a mere celebration.

On the motion of Mr. J. FitzGerald, seconded by General Brine, a resolution was passed, calling attention to the unsafe condition of electric communication in this country by overhead wires, and expressing the hope that members of Parliament would call on the Government to take measures to prevent the recurrence of the recent alarming disarrangements.

A vote of thanks to the lecturer brought the meeting to a close.

COMPANIES' REPORTS.

The Eastern Telegraph Company (Limited).

Report and accounts of the Directors for the half-year ended 30th September, 1886, to be presented to the twenty-ninth half-yearly ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, E C., on the 20th inst., at 1 o'clock:—

The revenue for the period amounted to £292,229. 17s. 8d., from which are deducted £81,025. 9s. 10d. for the ordinary expenses, and £53,965. 5s. 5d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £4,677. 3s. for income-tax, there remains a balance of £152,561. 19s. 5d., to which is added £4,079. 2s. 8d. brought from the preceding half-year, making a total available balance of £156,641. 2s. 1d. From this balance there have been paid—

	£	s.	d.
Interest on debentures and debenture stock	23,252	8	2
Dividend on preference shares	20,296	15	9
Two interim dividends of 1¼ per cent. each on ordinary shares	95 000	0	0
	£143,549	3	11

Leaving a balance of £13,091. 18s. 2d. which is carried forward to the next account. The revenue includes £16,600 dividend for the half-year upon the Company's shares in the Eastern and South African Telegraph Company, and also £3,570. 10s. net receipts for the half-year on the shares of the Black Sea Telegraph Company belonging to this Company. The cables of these companies are in good working order. The present accounts include the receipts for three months' working under the reduced tariffs fixed at the International Telegraph Conference in Berlin last year. The several sections of this Company's cables and the land lines in connection therewith are in good working order. The outlay in connection with repairs and renewals has been exceptionally large for the past half-year, mainly due to renewals of the Direct Lisbon line, upon which 191 knots of new cable have been used. Three-fourths of this cable have now been renewed out of revenue. The establishment of telegraphic communication with the British possessions on the West Coast of Africa by the African Direct Company was completed in September last. It is as yet too early to ascertain the probable traffic over the lines. In accordance with the provisions of the Articles of Association, two of the directors, George Garden Nicol, Esq., and John Denison Pender, Esq., retire by rotation at this meeting, and, being eligible, offer themselves for re-election. The auditors, Mr. Henry Dever, and Messrs. Quilter, Ball, and Co., retire, and offer themselves for re-election.

The Direct United States Cable Company (Limited).

Report of the Directors for the six months ended 31st December, 1886, to be presented at the nineteenth ordinary general meeting of the Company, to be held at Winchester House, 50, Old Broad-street, E.C., on Friday, the 21st inst., at 2 p.m.:—

The revenue for the half-year, after deducting out-payments, amounted to £19,603. 6s. 11d., against £38,115. 3s. 5d. (after similar deductions) for the corresponding period of 1885, being a difference of £18,511. 16s. 6d., against the half-year under review, owing to the reduced tariff referred to in the last report, the competition and low rates still continuing. The working and other expenses for the same period, including income-tax, &c., but exclusive of cost of repairs of cables, amounted to £16,354. 7s. 6d., leaving a balance of £3,248. 19s. 5d. as the net profit of the half-year, making with £3,050. 19s. 3d. brought forward from the previous half-year, a total balance of £6,299. 18s. 8d. For the corresponding half-year of 1885 the working expenses and other payments amounted to £16,631. 13s. 0d. An interim dividend of 2s. per share for the quarter ending September 30th, 1886, was paid on the 30th October, 1886. It is now proposed to pay for the quarter ending 31st December, 1886, a further interim dividend at the same amount per share; for this purpose recourse will be had to the reserve fund. A break occurred in the short section of cable on the 3rd August last, and was repaired on the 7th of September.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Jan. 12.		Business Done Week Ending Jan. 12. Highest.	Lowest.
Anglo-American	34,	35	35½	34
Do. Preferred	56½,	57½	59	56½
Do. Deferred	12½,	13½	13½	12½
Brazilian Submarine	10⅞,	11⅛	11	10 15-16xd.
Cuba	11¼,	11¾	11½	--
Do. Preference	18,	19	—	—
Direct Spanish	1⅞,	2⅛	—	—
Do. Preference	9½,	10½	—	—
Direct United States Cable	8⅝,	8⅞	8 15-16	8⅞
Eastern Telegraph	10⅜,	10⅝	10⅝	10⅜
Do. 6 per Cent. Preference	13¾,	14¼	14 1-16	13¾
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	10⅞,	11⅛	11⅛	10⅞
German Union	9,	9½	9 7-16	9⅛
Globe Telegraph and Trust	5⅛,	5⅜	5 5-16	5⅛
Do. Preference	12¼,	12¾	12½	12¼
Great Northern	13⅛,	13⅝	13⅜	13⅛ xd.
Indo-European	34,	35	34¾	34¾
Reuter's	7,	7½	—	—
Submarine	190,	200	—	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	8½,	9	—	—
Western Brazilian	7⅜,	7⅞	7¾	7½
Western Union 7 per Cent. 1st Mortgage	115,	120	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	½,	⅜	—	—
United Telephone	12½,	13	12⅞	12⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	—	—
Do. (fully paid)	4¼,	4¾	—	—
Swan	1½,	2	1½	—
Maxim Weston	5-16,	7-16	—	—

MISCELLANEOUS.

Telegraph Construction	39	40	39⅝	39½
India Rubber, Gutta Percha, and Telegraph Works	24	25	25	24½

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NOTES.

Exhibition of Telephony at Brussels.—This exhibition was opened to the public on the 14th inst. The number of exhibitors does not exceed thirty; but some interesting results will probably be forthcoming.

Fontainebleau.—A company has been floated in Paris for the introduction of electric lighting at Fontainebleau. Gaulard-Gibbs transformers are to be employed. 169 subscribers for 1,750 lamps have already been secured.

West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half-month ended the 15th January are £2,955, as compared with £2,639 in the corresponding period of 1886.

"Electricity and its Uses."—We have received from the Religious Tract Society a copy of the second edition of "Electricity and its Uses," by J. Munro, which has been revised and enlarged since its first appearance.

Sale of Varley Patents.—In our advertising columns particulars will be found as to the sale by private tender of the patents held by the Varley Electric Patents Proprietary (Limited), pursuant to an order of the Court of Chancery.

Tenders for Telegraph Material.—The Great Indian Peninsula Railway Company require tenders for telegraph materials. Specifications may be obtained on application at the Company's offices, 3, New Broad-street, E.C., and must be returned before the 30th inst.

The New Telephone Company.—The New Telephone Company has just carried out two private lines, each 6½ miles in length, between Margate and Ramsgate. The wires were erected by Mr. W. Covington, of Canterbury. The "Valve" instruments now appear to give perfection satisfaction.

Sale of Plant at the Colonial and Indian Exhibition.—We would remind our readers of the important sale, by Messrs. Wheatley Kirk, Price and Goulty, of engines, boilers, dynamos, and other electrical plant used at the Colonial and Indian Exhibition, which takes place on Wednesday and Thursday next.

The Post Office Telegraphs.—On Monday, the 17th inst., a notice was issued by the Post Office cancelling all previous notices as to delay in the telegraph service owing to the breakdown occasioned by the storm of Dec. 26th. The repairs have thus been completed in the space of three weeks. The telephone service in the metropolis is still in a disorganised condition.

Underground Wires in Germany.—The Berlin correspondent of *The Times* has received an official communication from the Minister of Posts and Telegraphs, asking him to state that fully one-half of the commercial messages pass over the underground wires in Germany, and that the scheme was originally planned from a commercial, and only in a secondary sense from a military point of view.

Globe Telegraph and Trust Company.—The directors of this company have declared the payment of an interim dividend on and after the 27th inst. of 3s. per share on the preference shares, less income-tax, and of 6d. per share on the ordinary shares, income-tax having already been deducted, for the quarter ended the 18th January. The transfer books will be closed from the 20th to the 27th inst., both days inclusive.

Amateur Photography at Telegraph Stations.—Messrs. G. M. Baines and S. S. Henry, of the Eastern Telegraph Company's station, Carcavellos, Portugal, have had the honour of photographing His Majesty the King of Portugal, Don Carlos, and Princess Amelia, whilst on a shooting expedition to that neighbourhood. The royal group was a great success, and does great credit to the operators, who have only practised the art during the past year.

King's College, London.—Prof. W. Grylls Adams, F.R.S., will deliver a course of lectures on magnetism, dynamic electricity, and electro-magnetism, and their applications to dynamo-machinery, electric lighting, transmission of power, &c., during the present session. A course of practical work in electrical testing and measurement with especial reference to electrical engineering will also be carried on under his direction in the Wheatstone laboratory. The lectures will be given once a week—on Mondays at 2 p.m.—and the laboratory will be open daily from 1 to 4, except on Saturdays.

Costly Economy.—In sending telegrams by the word rate, especially cable messages, it is possible to push economy too far. A lady of American ancestry, who is well known in certain circles, was recently suffering from severe illness. Some of her nearest relatives in New York cabled that if she was no better they would come over at once. The answer came "no better." On their arrival eight days later their feelings must have been of a somewhat conflicting character on finding the invalid entertaining a party of guests. The omission of a comma thus caused no end of expense, anxiety, and trouble.

Obituary.—We regret to announce the death of M. Ed. Blavier, Inspector-General of French Telegraphs, and Director of the School of Telegraphy at Paris. M. Blavier was also president of the "Commission on Improvements" attached to the office of the Minister of Posts and Telegraphs, and editor of the *Annales Télégraphiques*. M. Blavier has done a great deal of useful work in connection with French telegraphs, and as an electrician was one of the safest men in that country. His name is best known to English electricians in connection with a valuable modification of the "loop test" for determining the position of a fault in cable testing.

The Society of Telegraph-Engineers and Electricians. The first meeting of this society for the present session was held on Thursday, Jan. 13, at the Institute of Civil Engineers, Westminster, when the newly-elected president, Sir Charles Bright, delivered his inaugural address (the publication of which was commenced in our last issue, and is concluded this week). Previous to the delivery of Sir Charles's address a vote of condolence with Lady Bolton on her recent bereavement was carried. Prof. Forbes then moved and Mr. W. H. Preece seconded a vote of thanks to Prof. Hughes, the retiring president, to which Prof. Hughes briefly responded. The next meeting of the Society will be held on Thursday, 27th inst., at 8 p.m., when a paper on "Telephonic Investigations" will be read by Prof. Silvanus Thompson, B.A., D.Sc., member.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended January 14th were £3,719, after deducting the fifth of the gross receipts payable to The London Platino Brazilian Telegraph Co. The directors have decided to change the company's financial year from October to September, to January and December, in accordance with the more general rule, and in correspondence with the Brazilian Submarine Telegraph Company, with which this company has working agreements. The next account, therefore, will embrace a period of fifteen months—viz., from October 1st, 1885, to 31st December, 1886. The annual meeting of the company will not be held this month, but as speedily thereafter as the

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accounts can be prepared, which it is hoped will be in February.

IRON *v.* WOODEN TELEPHONE POLES.—The behaviour of the iron poles during the recent storms has somewhat disappointed the expectations of telephone and telegraph engineers, and has at least shown that the structures at present in use are of too flimsy a character for the strains which they may be called upon to undergo. It is a remarkable fact that during the last three weeks scores of cases have been visible in the metropolis where the iron poles have been bent and twisted into the most extraordinary forms, while the wires themselves have given way only on one side. On the top of a house at the southern end of Waterloo Bridge may still be seen a pole some thirty or forty feet in height, the upper half of which is bent very nearly ninety degrees out of the perpendicular. In this case the span upon one side is of great length, and the wires descend to a much lower level. In other cases the iron poles have snapped off short close to their bases. It thus appears doubtful whether the maximum economy is on the side of iron or wooden poles.

BRADFORD.—At a recent meeting of the Bradford Town Council, the Chairman of the Lighting Committee spoke as follows:—As to the supply of the electric light, he was aware that there were many applications to have premises lighted with electricity, and Messrs. Schmidt, Douglas and Co., had fitted up premises in the centre of a block of property from which they were able to supply shopkeepers in Kirkgate and Ivegate with the electric light. Hitherto the attitude of the Corporation had not been to encourage enterprise of this nature, nor had they done anything towards exercising the powers possessed by the Corporation in reference to the electric light. This was a "dog-in-the-manger" policy which, he thought, the Corporation ought not to persist in, but that either the electric light should be provided by the Corporation, or that others should be allowed to provide it. Holding this opinion, he had brought the matter before a meeting of the committee, but the consideration of it had been adjourned pending the settlement of some questions which had been submitted to the Board of Trade. When the committee again met this question would be decided, and they would, no doubt, either allow private firms, on payment of a royalty, to supply the electric light, or the Corporation would put down a plant of their own to supply it.

ELECTRIC LIGHTING AND THE GAS INTEREST IN THE STATES.—The following paragraph occurs in a review of the past year by the *Electrical World* of New York:—"Regarding the commercial progress of electric lighting during the last twelve months, the record of the work of the various companies engaged in it shows that it was marked with unprecedented activity, which will, I think, be continued. An interesting and, in many respects, important feature manifested during the year is the newborn friendship of the gas companies towards electric lighting. After years of bitter denunciation, they have at last recognised that the electric light has come to stay, and that if they would continue receiving their share of public patronage, they must furnish the electric light. Hence it has become a wide-spread practice for gas companies to apply for a change in their charters so as to enable them to furnish electric light in addition to gas. As yet this applies principally to the arc light, but it seems not improbable that the incandescent will soon also find favour with gas companies. We may, indeed, chronicle decided progress in this direction when, as has lately been the case, even journals devoted to the gas interests openly advocate the adoption of the electric light by the companies concerned." Another American journal contains a list of twelve gas companies who have recently filed petitions to be allowed to go into the electric lighting business.

ELECTRIC WELDING—A CURIOUS STORY.—Some few months ago, shortly after the announcement of Prof. Elihu Thomson's method of electric welding, various paragraphs appeared in the French papers hinting that very remarkable results in the same direction had been obtained in the laboratories at Creil. The germ of the invention was attributed to some Russian *savants* whose names were not given, but it was stated that they had received valuable assistance in the development of their ideas from the French electricians. The highly remarkable nature of this invention may be estimated from the statement that it was anticipated that the plates of an ironclad might henceforth be riveted under water. The actual facts of the case are now related in the *Bulletin International*, from which it appears that in the summer of last year a syndicate of Paris bankers sent a representative to study the Russian oil wells. While in St. Petersburg this gentleman met with certain individuals who succeeded in impressing upon him the importance of effecting the distillation of the crude oil in non-riveted boilers, and who stated that they were in possession of an electrical method which enabled them to construct such boilers. On the payment of a considerable sum down in cash, they consented to accompany the envoy to Paris, and preparations were made (at the cost of the Paris bankers) for experiments upon a large scale at Creil. These experiments ended in total failure.

THE BERLIN EDISON COMPANY.—According to *Industries*, the Berlin Edison Company have in their manufacture of glow lamps abandoned the old form of bamboo filament, and employ at present round carbon threads, treating them in the flashing plan, as is done in England. Messrs. S. Siemens and Halske also make similar lamps under licence. The company claim a life of about a thousand hours with an expenditure of energy of 3·3 to 3·6 watts per standard candle, and they are now turning out lamps at the rate of about a thousand per day, which, however, is barely sufficient for the requirements throughout Germany. Very few lamps of other types are seen in the larger Berlin installations. The Edison Company have hitherto been obliged to buy their dynamo machines from Messrs. Siemens and Halske, but with the first of this month the old agreement expired, and they are now free to obtain their dynamos from any other maker, or to build them in their own works. The latter policy will be adopted, all the preparations for the manufacture of dynamos having already been made, and their manufacture will be commenced as soon as the Board have given their formal sanction. The company have already experimentally manufactured various types of dynamos, and amongst these one with single horseshoe magnet placed vertically with the yoke in the bed-plate and the armature above, similar in arrangement to the machines made now by Gramme, Kapp, and Siemens. The company have also made arrangements for manufacturing plating machines.

A (REALLY) NEW TELEPHONE TRANSMITTER.—The remarkable results which were obtained by Prof. Hughes in his researches on superposed magnetism have not hitherto borne fruit in practice. It will be remembered that, at a meeting of the Society of Telegraph-Engineers in the year 1883, Prof. Hughes exhibited some steel magnets, consisting of four or more separate wires or strands held together at either end by a brass collar. These compound bars exhibited not the least trace of external magnetism until they were bent or twisted in the hands, when strong polarity was immediately mani-

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fested. By reversing the direction of the twist the poles were simultaneously reversed. We do not know whether Mr. W. J. Morton, of New York, has based his telephone transmitter upon these researches of Prof. Hughes, or whether he has independently discovered the peculiar properties acquired by steel which has been repeatedly magnetised with equal strengths in reversed directions. Mr. Morton's transmitter consists merely of a coil of wire and a steel diaphragm which has received superposed magnetism. Now, this diaphragm, according to the inventor, does not act by bodily to-and-fro vibration, but by the disturbance of magnetic equilibrium which results from the molecular vibrations which are caused by the sound waves. It would, however, be difficult to maintain that the diaphragm does not execute vibration in the usual sense, and it seems to us more probable that the two effects are conjoined. We obtain our description of this instrument from the *Electrical World* of New York. Whether the results are sufficiently powerful for practical purposes we are not told. The instrument may obviously be used more or less efficiently as a receiver.

AS OTHERS SEE US.—The following remarks occur in the course of a retrospect of the past year in the columns of the *Gas World*. Although the opinion expressed in the latter part of the extract is couched in terms far stronger than we should care to endorse, or are, indeed, in any sense justified by the facts, yet the warning may not perhaps be altogether superfluous:—"The tendency towards perfection in gas-lighting has not been so rapid as in electric lighting, but it must be borne in mind that the early controllers of the gas industry had to feel their way. They had to deal with forces the nature of which was imperfectly understood, and it was only when the chemist and the physicist came to the aid of the engineer that the industry began to bud and to blossom, and ultimately to develop into its present magnitude. True, the electrician has also to deal with forces whose nature he cannot altogether comprehend; but he has been greatly aided in his efforts to control and utilise them by the foremost scientists of the present generation, who have devoted their lives to the elucidation of natural phenomena, and who have so far succeeded that the work of the practical electrician in taking advantage of their discoveries has been greatly facilitated. Some one has observed that it is useless to prophecy unless you know. We do not know what the future of electric lighting may be, and therefore we have no inclination to don the prophetic mantle; but we may safely assert that, if with the mechanism now employed to obtain and use the electric current the acme of perfection has been reached, the day is yet far distant when gas engineers need seriously concern themselves about the new competitor. Yet they are not to imagine that their business cannot be injured by unscrupulous speculators. Quacks are to be found in every industry, and the electric lighting industry is no exception to the rule. Such men go about from town to town, and even appear upon the platform before learned societies, and plausibly discuss the possibility of economically introducing electricity. By wilfully perverting facts, or purposely ignoring them, these men lend themselves to a fraud which ought to be denounced in the strongest language. The year that has gone has not been free from the influence of much of this quackery."

VIENNA.—The recent conflict between the Imperial and the municipal authorities of Vienna with regard to the scheme for a central electric lighting station which has been undertaken by the Continental Gas Association, has now been terminated by an acceptance of the proposals of the company. According to *Industries* there are at the present moment seven distinct stations for the supply of electricity projected for Vienna. These are the following:—1. A central station at Neubad for running 15,000 glow lamps in the shops and dwelling houses of the inner town; contractor, Herr Fischer. 2. A central station in Blutgasse, close to St. Stefan's Cathedral, also with 15,000 glow lamps distributed in various newspaper offices, shops, some private houses, and the Government printing offices; contractors, Messrs. Siemens and Halske. 3. A small central station close to the Union Hotel, where accumulators will be used, the number of lights not yet ascertained; contractor, Mr. de Calo. 4. Imperial Continental Gas Association, close to the new Burg Theatre, for 14,000 glow lamps, worked by steam engines and direct driven dynamos in conjunction with a series of accumulators; the light will be used in the two principal theatres, the Opera House, the Emperor's Palace, and the offices of the gas company; contractors, the Gas Company. 5. A small central station in the Paniglgasse, for a number of glow lamps distributed in the neighbourhood; contractors, Messrs. B. Egger and Co. 6. A central station in the suburb Mariahilf, for 12,000 glow lamps; steam power, 1,000 horse-power; there will be twelve dynamos, each giving 480 amperes and 125 volts; contractors, Messrs. Kremenezky, Engländer, and Leistler. 7. A central station at the water works in Nussdorf; number of lamps not yet ascertained; here transformers on the Zipernowsky system will be used. The conditions to which electric light contractors are, however, asked to submit are very onerous; for instance, the gas company are asked to pay a rental for the right of way for their street mains of 1kr. (about ·19 of a penny) per annum for every yard of conductor, and for every service lead between mains and houses 1fl. per annum. In addition, they are asked to hand over to the town 5 per cent. of their gross income from the sale of electricity. It is further proposed that, by giving a year's notice, the town can at any time compel the company to sell them the undertaking.

ELECTRIC LIGHTING AT THE COLONIAL AND INDIAN EXHIBITION.—The report of the Committee on Electric Lighting of the Colonial and Indian Exhibition has recently been issued in the form of a document marked "private and confidential," consisting of 12 folio pages, and containing much detailed information—including the amount of the fines incurred by certain of the contractors for various irregularities, which were mostly of a minor description. We are, however, enabled, without any breach of confidence, to subjoin a few details from certain portions of the report. It is already known that the firms who took part in the contracts were the following:—Messrs. Davey, Paxman and Co.; the Anglo-American Brush Company, Messrs. Crompton and Co., the Pilsen-Joel Company, the Electrical Power Storage Company, Messrs. Elwell-Parker and Co., and Messrs. Galloway and Sons. Mr. J. H. Cundall, and Mr. G. Schultz, were the electrical engineers appointed by the committee to superintend the operations. The general results are thus referred to:—"The Committee are glad to be able to report that no accident has occurred during the whole period of working, nor have there been any but trifling local interruptions of the light for brief periods. Moreover, there has not been even an alarm of fire in any one of the departments of the building." This statement will be admitted to be highly satisfactory, and to reflect the utmost credit upon all concerned. For the arc lighting altogether 28,300 yards of wire were used, and it is stated that the "average insulation on a fine dry day was 450,000 ohms, and on a wet day 300,000 ohms." For the incandescent leads 16,235 yards of wire were used, and the insula-

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tion varied between 25,000 and 2,600 ohms. The report reads as if in each of the two cases the various circuits were joined up continuously, in order to measure the entire insulation resistance; but we do not know whether this was actually the case. In the illumination of the gardens 8,034 glow lamps were employed, and in the buildings themselves 1,851 lamps were hung, the average number in use being 1,667. These 1,667 lamps illuminated an area of about 106,447 square feet, and consumed 102,750 watts, being at the rate of about 0·9 watts per square foot. A large proportion of the lamps had already been used in the previous exhibitions, so that the record of their life is not very instructive. It is, however, satisfactory to note under these circumstances that the average life of lamps from the opening of the Exhibition (including all accidents) comes out as high as 1,200 hours. The majority of these lamps were either of the Edison-Swan or the Woodhouse and Rawson make, and there were also some Victorias and some of the old type Edisons. On the whole the technical portion of the report has been well drawn up, but in some parts it is difficult to obtain real information from it. For instance, in the appendices relating to the performance of the E.P.S. cells, it is necessary to undertake a careful collation of the various figures in the separate tables before the actual efficiency of the battery can be arrived at. We could have wished that the report had appeared at a somewhat earlier date, and also that it had not been considered necessary to treat much of it as "private and confidential," but it affords us much pleasure to recognise the valuable testimony which it bears to the very high standard of skill and efficiency which modern electrical engineering has in general attained.

THE VIEWS OF THE UNITED TELEPHONE COMPANY.—The *Pall Mall Gazette* publishes the following account of an interview between Mr. Brand, the chairman of the U. T. Company and a representative of that journal on the subject of the recent breakdown of the overhead wires:—"What view, Mr. Brand, has the Stock Exchange taken of the breakdown in your system?" "There has been a fall of ¾ to 1; but it shows how much we are progressing in public favour that when the storm of a year ago broke many of our wires our shares went down from 2 to 3. There is, however, no reason why there should even be a fractional fall. The cost of our repairs will certainly not exceed £5,000, while the drop on the Stock Exchange is equal to at least £60,000." "The complete dislocation of your system must, of course, have caused great inconvenience now that you have accustomed business men to its use?" "That is true, but the whole system did not break down. None of the cables gave way, and we had as many as 12,000 messages on the first day after the storm, and as we have spared no effort or expense to re-establish communications, that number was very speedily added to. We first of all directed our attention to making good the principal pole routes, as we term them, and after we had attended to the great highways, the mending of individual wires was proceeded with. We shall very shortly have our whole communications restored; and, considering the unfavourable weather and the shortness of the working day, that is not a bad result. Our trunk lines stood the strain admirably, although here and there poles bent or broke; but the weakness was as often as not in the roof, rather than in the lines and their supports." "Have you heard of any accidents in consequence of the breakage of wires?" "No, not a single accident. The storm has demonstrated that the dangers from overhead wires are merely imaginary. Of course, it is possible that there might be an accident, but the risk from a falling chimney-pot is much greater than from a broken wire. So far as I can learn, there is only one undoubted case on record, and that accident was caused, not by the wire while falling, but by its end being wound round a lamp-post by a passer-by, and an unlucky omnibus driver coming in contact with it, had his head knocked off, or something of that sort." "Is it possible for you to strengthen the overhead wires so that they may stand the strain better?" "We are doing what we can, but we have many obstacles to overcome. The way-leave is one of the greatest difficulties. The roofs are of varying heights, which causes unequal strains upon the wires, and as we cannot go where we please we have often to make long spans. If we had perfect freedom granted us by the Legislature we could lessen very materially the risk of a breakdown, and reassure the public on the score of safety. Our plan would be to increase the number of poles, lessen the span, and equalise their length. You will see at once that the wires would be much more stable then. I have every hope that the Legislature will increase our powers when public opinion is fully educated. The underground scheme is of course the great alternative, but to that there are both scientific and financial objections. An underground system would be very costly, and would necessitate a very large increase in the subscription, which would militate against the extension of the telephone. But that apart, it is questionable whether the telephone will work with the wire underground." "What is the extent of the telephone system in this country?" "That may best be gauged by giving you the number of instruments in use. The United have within the area of their patent licensed up to the close of last year between 100,000 and 120,000 instruments. That is a development which, while not so great as in America, is enormous. Mr. Raikes recently spoke of giving greater facilities to the telephone. I am not aware in what direction he proposes to do so, but if we are not handicapped in any way, there is no reason why we should not outstrip America."

THE WESTINGHOUSE COMPANY AND THE STANLEY ALTERNATING CURRENT DYNAMO.—It has already been announced that the Westinghouse Company of the United States have been engaged for some time past in making preparations for the introduction of the system of distribution by transformers, upon the most extensive scale. We understand that in addition to the Gaulard-Gibbs patents, the company has recently acquired the patent rights in several inventions relating to the use of alternating currents, both in this country and in the States. The validity of certain of the United States patents taken up by the company has, however, been challenged both by Brush and by Edison, and it is expected that protracted litigation will ensue, each of the parties being well provided with the sinews of war. The first step has already been taken by Edison, who commenced legal proceedings on the 24th ult. It is to be hoped that these disputes will not retard the development of a system which in many cases gives promise to effect a very considerable economy in central station lighting. The alternating current machine which the Westinghouse Company will employ has been designed by one of their own electricians, Mr. W. Stanley, assisted by Mr. Shallenberger, and others. The machine is said to have a remarkably large output; weight for weight the figures mentioned to us are as much as three or four times as good as those of modern low-tension continuous current machines of English make, while the selling price, it is said, will not exceed 30s. per horse-power for moderate sized machines. We hope shortly to give drawings and detailed description of this interesting machine, and in the meantime we take the following further particulars from the *Electrical Engineer* of New York:—"The body of the armature is cylindrical, 23in. in diameter and 12in. face, and is formed of discs of iron magnetically separated from each other, the con-

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ducting wire being wound in flat coils upon its face. The field magnets, 16 in number, are arranged in a circle, with their poles facing inward toward the armature, and in close proximity thereto. The dynamo is driven at the rate of 1,080 revolutions per minute, thus giving 17,260 alternations of the current per minute, or 288 per second. The weight of the entire machine is about 7,000lb., and the total weight of copper wire on the armature and field-magnet about 800lb. The potential at the terminals of the dynamo when running is maintained at about 1,100 volts. An independent exciter is employed for the field, consisting of a small Stanley direct current dynamo of 150 volts and 10 amperes, driven at 1,800 revolutions per minute. The alternate dynamo and exciter are both belted to the shaft of an 18 by 16 Westinghouse automatic engine of 200 horse-power, and running at 276 revolutions." In the same journal appears a letter from Mr. Stanley, from which we make the following extract:—"While engaged in developing some of the 'modifications' of the Westinghouse system, I determined to design a constant E.M.F. dynamo of the alternating type, having from 16,000 to 20,000 reversals per minute. There seemed to be a general opinion that an alternating current dynamo with an iron-cored armature would result in failure, as the cores when subject to 16,000 reversals of polarity per minute would heat too greatly for practical use. It was found upon trial that the iron core instead of heating from self-induction, reduced the self-induction to a practical zero. That the great number of reversals per minute did not increase the magnetic lag; and that the calculations used in determining the electrical data of direct current machines were applicable to dynamos of the alternating type." From this extract it would almost appear that Mr. Stanley's machine belongs to that order of invention (of which we have had so many remarkable examples from the States) in which a high degree of practical success has been attained with a comparatively slender acquaintance with theory. We base this estimate on Mr. Stanley's use of the term "self-induction," a phenomenon which it would appear that he has confused with Foucault currents. We are quite ready to believe that an alternating machine can be built with iron in the armature, and it is, indeed, obvious that this is the only way in which an economical machine can be constructed, but we are at present somewhat sceptical as to the result being to reduce the self-induction of the armature "to a practical zero." We may remark, in conclusion, that it is too often taken for granted that self-induction is an unmitigated evil. It is true that self-induction, as a rule, restricts output, but it wastes no energy, and its presence may at times be positively advantageous.

The Post Office and the Recent Storm.—The *Pall Mall Gazette* publishes the following information obtained from the engineer-in-chief of the Post Office by a representative of that journal as to the effects of the recent snowstorm:—Of course there was a good deal of grumbling at the necessary delays, but on the 28th there were 3,776 messages handed in at the Stock Exchange which were sent over the ordinary wires. The following comparative figures certainly speak well for the energy of the department. They relate to the messages sent in the metropolitan district, through which the chief offices are connected with the central telegraph office by underground wires:—

	1885.	1886.
December 27 (Boxing Day)...	6,000	6,800
„ 28	9,700	9,900
„ 29	9,000	9,700

For the week the total messages numbered 670,000, and for the corresponding week last year 710,000; but, as the Bank Holiday did not fall in the same week last year, the difference is more than accounted for. For the week ended Saturday last the number of messages was 803,000, as compared with 736,000 last year, notwithstanding the fact that many wires were still stopped and that senders were warned that their messages would probably be delayed. The department has been able to have this good record while the wires were down by the free use of the Wheatstone instrument. Every means were used to get messages through, no matter how circuitous the route or involved the method. Some were sent on by train for part of the distance and then telegraphed, and others were first wired, then carried by train, and again wired. Some messages from Paris reached London *viâ* New York. The cost of repairs will be heavy, but it will not fall wholly on the Telegraph Department. All the wires along the railway lines are maintained by the respective railway companies, and the Post Office pays for maintenance an inclusive charge of £1 per mile per annum. They will therefore have to make good the wires on the lines. Those on the highways are, of course, maintained by the Post Office, and to repair and improve these where it is thought desirable something under £10,000 will probably be required. It may surprise some to learn that while Germany, which has been put so prominently forward, has 22,000 miles of underground wires, the English Post Office has a total length of full 20,000 miles. All the trunk lines are carried out of London underground, some to the distance of five miles from the Post Office, some ten, and some twenty, and they then emerge above ground. In every large town the same system is followed. We do not, of course, carry any of our wires under the high roads, as Germany presumably does; and from a military point of view, except in the contingency of a storm, there is no increased security by this method, for the route of underground wires could easily be discovered. It is the fact that Portsmouth, Plymouth, and Chatham were isolated for several days, and Aldershot for a single day, but had there been an emergency the first attention would have been given to these places, and the communications could have been rapidly restored. In certain possible contingencies it might be well to have underground communications with our naval and military stations, but the outlay would be a very heavy insurance premium indeed. The cost of an underground wire is £350 per mile, as compared with £35 overhead, while every additional wire costs £14 underground and £10 over. Beyond this, underground wires diminish the speed from 25 to 75 per cent. over long distances. By the multiplex system six messages are sent by one wire simultaneously when overhead, but in the case of an underground, for a distance of fifty miles, say to Brighton, scarcely two messages can be sent. Thus there is an enormous waste in the case of the underground to be added to the first cost, and, contrary to what is generally believed, the cost of maintenance, including renewal, is but little different to the cost of maintenance of overground wires. The telegraph authorities have given the subject their fullest consideration, and it is some time now since they mapped out the whole country and calculated the cost of a general underground system of wires to connect the principal towns in the United Kingdom together, and London with the landing places of the submarine cables. This could not be done for a less expenditure than £1,750,000 to £2,000,000, and, as the gross annual revenue of the department only amounts to the larger of these two sums, how to recoup itself for such an outlay becomes a difficult problem. If it were urged that we should at first, in view of political complications, only connect the Continent by underground wires, our great business towns would naturally claim the same privilege. No doubt the underground system will extend, as there is practically no room left on many roads, but its general adoption is yet in the far distance.

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Continued from page 211.)

Many motors have been constructed in which masses of iron are made to pass across the field of an electro-magnet, or number of electro-magnets, either with a reciprocating motion or with a continuous rotation, and by means of a "make-and-break" arrangement a current, from a battery or other source, passes round the coils of the electro-magnet, and excites them when the iron armatures are approaching the magnets, but the current does not flow while the pieces of iron are receding from the magnets, so that work is done on the iron while approaching a magnet, but its motion is unopposed as it recedes. In these motors, however, there is a great waste of power on account of the currents induced in the armatures, and the energy wasted in magnetising and demagnetising the field-magnets. They can only be employed when very small power is required and its expense is of no consequence. A similar remark applies to those motors in which one set of electro-magnets revolves in the neighbourhood of another set, the current in the revolving set being reversed at each half revolution so that the force acting upon it is always in the direction of its motion.

To obtain high efficiency in a motor the only conductor moving in the magnetic field should be the wire which conveys the currents, the magnetism of the field-magnets should be maintained constant, and in no case should a mass of iron be alternately magnetised and demagnetised, though there is little objection to this if the iron consists of thin discs insulated from each other and with their planes parallel to the lines of force in the field.

When a dynamo is employed to drive a motor it frequently happens that the dynamo is kept running continuously, but the motor is allowed to run only at intervals. It has been pointed out that to obtain high efficiency the resistance both of the dynamo and the motor must be kept very low. If the speed of the dynamo be kept constant the E.M.F. produced will remain nearly constant, and when the circuit is completed with the motor at rest, the current will be very great indeed, and either the engine will be stopped by the enormous load thrown upon it or the armature will be injured by excessive heating. To obviate this it is usual to introduce resistance coils of iron or German silver so adjusted that the whole E.M.F. of the dynamo cannot produce an injurious current through the whole series of coils. The coils are arranged so that they can be thrown out of circuit one by one by a suitable switch as the speed, and therefore the "back E.M.F.," of the motor, increases. When the motor is started the whole series of coils is introduced into the circuit. As the speed increases the switch is moved so as to throw out one coil after another, until all the resistances are thrown out, when the speed of the motor approaches that at which it is intended to be driven. The dynamo is kept running uniformly the whole time. To take a numerical example :—Suppose the dynamo running at 1,000 revolutions per minute to give an E M.F. of 120 volts, that the greatest current we wish to allow is 60 amperes, and that the resistance of the circuit, including the dynamo and motor, is $\frac{2}{3}$rds of an ohm. Then if the motors are stationary, the current, when it became steady, would be 180 amperes instead of 60 amperes. Self-induction, especially in the field-magnets of the motor, will prevent the current from instantaneously rising to this limit when the circuit is completed, but it would reach it in a short time if the motor were prevented from running. By introducing four resistance coils, each of $\frac{1}{3}$rd ohm resistance, the resistance of the whole circuit will be raised to two ohms, and the current reduced to 60 amperes. As the speed of the motor increases, its back E.M.F. will come into play, and when this has reached 20 volts, corresponding to a current of 50 amperes in the circuit, the switch may be moved forward so as to throw one of the coils out of the circuit. The resistance will then be $1\frac{2}{3}$rd ohms, and the resultant E.M.F. in the circuit 100 volts, so that the current will be again 60 amperes. As the speed increases the current will diminish, and when the current has fallen to 48 amperes the E M.F. will have fallen to 80 volts, or the back E.M F. of the motor will have reached 40 volts, and the switch may be moved forward so as to throw the next coil out of circuit. The resistance will then be $1\frac{1}{3}$rd obms, and the E.M.F. 80 volts, so that the current will again be 60 amperes. When the current has fallen to 45 amperes the back E.M.F. will have increased to 60 volts, and the next coil may then be thrown out. The last coil may be thrown out when the current has fallen to 40 amperes, for the back E.M.F. will then have reached 80 volts, and the resultant E.M.F. in the circuit will be 40 volts, which in a circuit of $\frac{2}{3}$rd ohm resistance will produce a current of 60 amperes. If the load upon the motor is so small that the speed increases beyond this the current will continue to diminish. If the load be uniform this must be the case, for if the speed has been attained with a current of 40 amperes it is clear that a current of 60 amperes will increase it, and therefore increase the back E.M.F. Suppose that the speed increases until the current has fallen to 45 amperes, and then remains steady. Since the resistance of the circuit is $\frac{2}{3}$rd ohm the resultant E.M.F. must be 30 volts, and the back E.M.F. of the motor 90 volts. The horse-power employed in driving the current against the resistance of the circuit—that is, in developing heat in the conductors, will be $\frac{30 \times 45}{746}$, or 1·81; that employed usefully in driving the motor will be $\frac{90 \times 45}{746}$, or 5·43, while the whole electrical horse-power developed in the dynamo will be the sum of these two quantities, that is $\frac{120 \times 45}{746}$, or 7·24, so that 75 per cent. of the electrical energy developed will be usefully employed in driving the motor. The engineer in charge of the motor might be provided with an ampere-meter, or current measurer, enabling him to observe the whole current in the circuit, and might switch out the resistance coils as above indicated, or he might have a volt-meter connected with the terminals of the motor armature, and therefore reading the back E.M.F. of the motor increased by a small quantity equivalent to the product of the current into the resistance of the armature. For each 20 volts indicated by the voltmeter the engineer should switch off one of the resistance coils.

Sometimes the E.M.F. of the dynamo is so great compared with that required to maintain in the circuit the maximum current permissible, that it would be dangerous to allow the circuit to be completed even for a few seconds when the motor is at rest without introducing extra resistance. In such a case an automatic cut-off should be provided. This is easily arranged by causing the current to pass through a small coil of wire, which, attracting a piece of iron, pulls over a lever and breaks the circuit as soon as the current exceeds a certain amount. The circuit can then only be again completed by the attendant. When the power of the engine employed to drive the dynamo is not much in excess of its rate of working when the system is running properly an additional safeguard to the electrical appliances is introduced, for if the primary current much exceed its proper limit the engine will be stopped. This may, however, be accompanied by the slipping or breaking of the belts, and ought to be avoided.

To render the variation of the current as small as possible the resistance coils should not all be equal, but that which is first thrown out should have the greatest resistance, and the resistance of the others should successively diminish, so that if r_1, r_2, r_3, r_4 represent the resistance of the coils, r_4 being that of the coil first thrown out of circuit, and if R denote the resistance of the rest of the circuit the five quan-tities,

$$R,\ R+r_1,\ R+r_1+r_2,\ R+r_1+r_2+r_3,\ R+r_1+r_2+r_3+r_4,$$

may form a geometrical progression.

Soon after Faraday's discovery of the induction of currents attempts were made to obtain currents of sufficient strength to be of practical value by the motion of a coil of wire in a magnetic field. When the field is sustained by a permanent steel magnet, the apparatus is called a magneto-electric machine. A simple form of this class of machine is that ordinarily used for medical purposes. It consists of a fixed horse-shoe magnet, before the poles of which two coils of wire are made

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to revolve. These coils are furnished with iron cores which are connected at one end, so that the coils and iron form an arrangement precisely similar to an ordinary electro-magnet, only that the wire is much finer than that usually employed in winding electro-magnets. When the bobbins are exactly opposite the poles of the steel magnet, most of the lines of force of the magnet, instead of passing from pole to pole through the air, take the longer but less resisting path offered by the iron cores of the coils and their connecting piece, and thus pass through the middle of all the turns of wire in the coils. When the bobbins have been turned through a quarter of a revolution there will be no lines of force passing through them, and when they have been turned through half a revolution they will again be opposite the poles of the steel magnet; but their positions will be reversed. The lines of force will, therefore, pass in the opposite direction through the turns of wire. Throughout the whole of this half revolution, therefore, there will be a current flowing in the same direction in the coils, for the effect of diminishing the number of lines of force passing through in one direction is the same as that of increasing the number passing through in the other direction. As the bobbins pass the poles of the steel magnet the mumber of lines of force traversing them will be the greatest possible, and will for an instant be neither increasing nor diminishing, but as soon as the bobbins have passed the poles the current will begin to flow in the coils, but in the opposite direction. Hence, the direction of the current will be reversed at every half revolution, viz., when the bobbins pass the poles of the steel magnet. By placing a commutator upon the revolving shaft which carries the bobbins, the connections of the ends of the coils of wire with the external circuit may be reversed at the same instant as the currents in the coils, and the currents in the external circuit will then always be in the same direction.

The magnets of magneto-electric machines of this class are generally furnished with a sliding keeper. This is a bar of iron which can be brought in contact with the poles of the steel magnet, or can be removed to a considerable distance from the poles. Since this keeper is much shorter than the iron cores of the revolving bobbins with their connecting piece, it follows that when it is in contact with the poles of the magnet most of the lines of force will pass through it, and very few through the bobbins, even when they are opposite the poles of the magnet. Hence, the induction currents will be feeble. On causing the keeper to recede from the magnet a larger percentage of the lines of force will pass through the bobbins, and the induction currents will be correspondingly strengthened. When the machine is not in use the keeper should be placed in contact with the poles of the magnet, to prevent the loss of magnetism which is otherwise liable to take place. The ordinary magnéto-electric machine employed for medical purposes is a familar example of this class of machine (Clarke's).

The Siemens armature, as constructed in 1857, consists of a cylinder of soft iron, with two wide grooves cut in opposite sides. In these grooves wire is wound longitudinally so that the wire, except where it crosses the ends of the cylinder, is parallel to the axis of the cylinder. This armature is made to revolve in a cylindrical space which nearly fits it, and which is bored between two blocks of iron placed a short distance apart, and forming the pole-pieces of a horse-shoe magnet. As the armature revolves the lines of force pass from pole to pole of the magnet through the iron, and, therefore, through all the turns of wire wound on the armature. Hence, there will be currents induced in the coil of wire which will be reversed at every half revolution. In this machine a much greater number of lines of force can be made to pass through the coil than in the machine above described.

(To be continued.)

THE AMERICAN BELL TELEPHONE COMPANY.—During the year 1886 the American Bell Telephone Company supplied 42,306 sets of instruments, and had 19,916 returned, showing a net increase of 22,390. Last year, owing to exceptionally heavy returns, the net increase was only 4,153.

PRACTICAL DEDUCTIONS FROM THE FRANKLIN INSTITUTE TESTS OF DYNAMOS.*

BY CARL HERING.

(Concluded from page 170.)

The following assumptions were made, as the accurate data for deducing the same were wanting. The speed in the Edison No. 4 machine was not given in the report; that given here is the speed at which the makers say the machine is to be run, and it is assumed that the speed must have been very nearly this in the test. The percentage of the whole circumference of the armature which is embraced by the pole-pieces was, in the Weston machines, assumed to be about eighty per cent., as this was the proportion in some arc-light machines of the same makers, which we understand have the same type of frame. The distance between the pole-piece projections was determined from this in the Weston machines. In the Edison machines, the length of the pole-pieces and the armature-core was deduced from the statement in the report giving the length of useful wire in a coil; it was assumed that by the term "useful wire" was meant that which lies directly between the pole-pieces and the armature-core. In the Edison machines, it was assumed that the length of the armature-core was the same as that of the pole-pieces; in the Weston machines, this was the case.

As the electromotive force induced in an armature is dependent upon the amount of magnetism passed through per second, the first questions in designing armatures are: How great may the velocity of the moving wire be? What must its length be? What must the intensity of the field be? &c.

The first of these, the velocity of the moving wire—commonly called the "conductor or inductor velocity"—depends on the distance of the active wire from the centre of the shaft, and on the number of revolutions of the armature. It may be calculated from the speed and the mean of the external diameter and the diameter of the core. In the table (the table here referred to was given in *The Electrician* of Dec. 31, 1886, p. 170) the horizontal column *a* contains the external diameters, *b* the internal, and *c* the mean. From this mean value the circumference in feet was calculated, which, when multiplied by the speeds *d*, and reduced to seconds, gives the inductor velocities in feet per second, in column *e*. From these values, it is seen that the Edison armatures have a higher velocity of the moving wire; also, that it is preferable to obtain the high inductor velocity by making the diameter as great as practical, rather than to increase the number of revolutions, as will be seen by comparing the small, high-speed armature of the Edison No. 4 with the large one of the Nos. 10 and 20.

To obtain a constant by means of which the length of wire may be calculated, the total electromotive force in volts which was generated has been divided by the length of that part of the wire in which it is generated. This wire will be termed the "active wire," and, in these deductions, has been limited to that portion of the armature wire which lies directly between the pole-pieces and the armature-core. Strictly speaking this is not quite correct, as some induction does undoubtedly take place in some parts of the wire lying at the ends of the armature, and also in some of the longitudinal wires which are not directly between the armature-core and the pole-pieces; but the induction in both of these parts is presumably so small as compared to that in other parts that it may be neglected, especially as the constants are to be applied to similar armatures, thus eliminating this error. The length of the active wires was calculated from the following proportions:—Column *f* gives the number of coils or commutator-bars, *g* the number of turns per coil, and *h* the resulting total number of turns on the armature. The proportion of these coils which are active is calculated from the distance between the pole-piece projections, column *i* and the circumference determined from the diameters in column *a*; the ratio of this is given in column *j*, in percentage of the circumference of the armature which is active; this will also represent the percentage of the number of windings which is active. Column *k* gives the length of a pole-piece in inches, which is the same as the length of the armature-core. From

* From the *Journal* of the Franklin Institute for December.

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these the total length of the active wire in feet can be calculated, remembering that every turn of wire on the armature represents twice the length of the pole-piece; but as the two valves of the armature-wires are in multiple arc, only half of this induces the whole electromotive force. The total electromotive force in volts, given in column *l*, is then divided by this half length of active wire in feet, giving the induction in volts per foot in column *m*. As this induction is slightly different in different positions of the wire with referenee to the pole-pieces, these results give the mean value. They show that the induction is considerably higher in the Edison than in the Weston machines; also, that it is very nearly the same in all the Edison, and nearly the same in the three Weston machines.

These constants are dependent on the velocity of the inductor, for it is evident that if the latter were higher the induction would be increased. In order, therefore, to properly compare these constants, it is necessary to eliminate the velocity by dividing these figures by the velocities in column *e*, thus giving the volts per foot which would be induced (in the respective fields) at a uniform velocity of one foot per second. This is given in column *n*, and shows the number of volts induced per foot for an inductor velocity of one foot per second. These may be compared with each other as the velocities are the same. They show that at the same velocity the induction is better in the Edison than in the Weston machines; also that the values agree very closely for all the Edison, except for the No. 4 machine, which may possibly be attributed to the number assumed for the speed, which was not taken in the test. For the Weston 6 M it is lowest, which is no doubt due to a less intense field.

The next question which naturally arises is, what was the intensity of the field in these machines? This may be determined as follows: We know that a volt is 100,000,000· times the unit of electromotive force in the absolute system, and also that one absolute unit of electromotive force is generated when a wire cuts lines of force at the rate of one per second; therefore, one volt is induced if a wire cuts 100,000,000· lines of force per second. As we know the number of volts in one foot (column *m*) in these machines, and also the number of feet moved through in one second (column *e*), we can readily calculate the intesity which the field must have had to induce that number of volts in one foot. To illustrate this, suppose the velocity was one foot per second, and that the induction was one volt per foot at this velocity, then it is evident that the surface moved over by one foot of wire in one second—that is, one square foot—must contain 100,000,000· lines of force; or, if the induction was two volts per foot, there must be 200,000,000. lines of force in this space, as this number must have been cut per second to generate two volts. Dividing this number by 144 will give the mean intensity of the field in number of lines of force per square inch. These figures are given in column *o*. They show that with one exception all the Edison machines have very nearly the same intensity of field; also, that it is somewhat lower in the Weston, especially in the 6 M machine; but, as will be seen, it is more economically obtained in this one, which indicates that it was probably not over saturated.

These values might also have been obtained by multiplying those in column *n* by 100,000,000· and dividing by 144, which is equivalent to multiplying them by 694,444. This will be seen by considering the principles of the deductions.

The total useful amount of magnetism in the whole field is evidently the intensity per square inch multiplied by the size of the field in square inches. As the intensity has been calculated from the amount of induction, the amount of magnetism thus obtained does not include the leakage of the magnetism—that is, those lines of force which are not cut by the armature wire; it therefore represents the useful magnetism only. The same lines of force which enter the armature at one pole-piece pass through it to the other pole-piece, and therefore the total number of lines of force is the intensity multiplied by the curved area of one pole piece. These figures are given in column *p*, and are deduced from columns *o*, *a*, *j* and *k*. The magnetism increases with the number of volt-amperes which the machine generates.

This amount of magnetism is generated at the expense of a certain quantity of electrical energy in the field-magnets. In order to get some approximate values for calculating roughly how much electrical energy will be required for generating in practice a certain amount of magnetism in similar fields, the figures in column *p* may be divided by the amount of energy in volt-amperes that was required in these cases to generate the respective fields. In the report the figures in column *q* are given, which are the energy in horse-power consumed in the fields. Unfortunately the resistance of the field without the regulator-box was measured only in one machine, so that the energy given here represents more than that used in the field-magnets themselves, thus introducing an error in all the deductions made from these values. It is presumed, however, that at full load the resistance in the box was not large, so that the error will probably be small. Reducing this energy in the field to volt-amperes, and dividing it into the amount of magnetism, gives the number of useful lines of force generated per volt-ampere in the field. These are given in column *r*. As they depend on so many different proportions of the parts of the field and magnet-coils, and also in a measure on the armature, they might vary considerably for different types of field-magnets, and can therefore be used only in making rough preliminary calculations. They agree tolerably well for these fields, except for the Weston 6 M, which is evidently better proportioned than the others. As these figures are the ratio of that which is produced to that which is required to produce it, they may be said to represent the *relative* efficiencies of the different fields, in which sense they represent no absolute efficiencies, but serve simply to compare the efficiencies with one another. In the Edison machines, we believe, wrought iron alone is used, while in the Weston both wrought and cast iron were formerly used together, and we presume were used in these machines also. Possibly the iron in the field of the Weston 6 M machine is not over saturated, which may be the reason of its high efficiency of field.

The wires of the armature being wound repeatedly around it, pass through the same field a number of times, thus utilising the same field in one revolution for successive inductions in the same wire. This number of turns, as given in column *h*, multiplied by column *j*, may therefore be said to represent the economic use of the field; it does not follow, however, that the best armature is the one having the greatest number of turns on it, as it is quite the reverse; other more important considerations, such as self-induction, sparking, &c., require that the number of turns of wire be as small as practicable.

In deducing the number of volts per foot, only the active wire was taken into consideration. In designing armatures it is therefore necessary to know what the proportion is between the active and the total length of the wire, for if the active length is determined first from the number of volts to be generated and the induction per foot, we must find what the total length is in order to determine the resistance or cross-section of the wire. This proportion of active to total length will evidently depend on several dimensions of an armature, and will therefore vary somewhat in different machines. For these machines it was determined as follows:—Column *s* contains the mean length of wire in one turn (where several smaller wires are in parallel they were considered as one); this multiplied by the number of coils in column *f* gives the total lengths in column *t*; these divided into the active length in column *u* give the percentage in column *v*. From the latter it will be seen that the economy of the wire is considerably better in the Edison than in the Weston, and that it is best in the Edison No. 20, the proportion between the length and diameter of the armature being greatest in this one. Most of the proportions from which these percentages have been deduced were given by the makers.

The density of the current in the armature wire can be determined from the diameters of the wire in column *w*, the number of wires in parallel in a coil in column *x*, and the total current in the armature in column *y*. Dividing the latter into the double area of cross-section of the wire in square mils., or the double sum of the cross-sections of the parallel wires, gives the number of square mils. per ampere in column *z*. These numbers vary somewhat with the current and with

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several other proportions; they should therefore be used only as a general guide, or for making preliminary calculations. The best method for determining the cross-section is to find the resistance from the amount of energy which is allowed to be lost in the armature, which together with the total length of the wire as determined from the induction per foot, &c., gives the required cross section.

The percentage of energy in the armature as taken from the report is given in column *A*. Those in which the loss is least, Weston 6 WI and Edison No. 10, have the greatest area of cross-section of wire per ampere (column *z*), while the one in which the loss is greatest, Weston 7 M, has the least cross-section per ampere. This relation does not necessarily exist between them all, as the percentage of loss depends also on the induction per foot of wire, and therefore on the length of the wire.

The relative efficiencies of these armatures, as inductors, may be seen from the figures in column *C*. The efficiency as an inductor, apart from that as a converter of energy, is greater the larger the total amount of electrical energy induced (column *B*), and the less the amount of wire necessary to effect this induction; it may therefore be expressed by the quotient of the two. The figures in column *C* have therefore been calculated by dividing those in column *B* by the lengths in column *t* and by the double area of cross-section determined from columns *w* and *x*, the decimal point being changed to reduce them to a convenient form. By themselves these figures represent nothing, but by comparing them with one another they show which of the armatures are the best proportioned as inductors. They show that the Edison are considerably better proportioned than the Weston. The most efficient armature is, strange to say, the smallest one, Edison No. 4, which is no doubt due to its having the most intense field (column *o*), the highest speed (column *d*), and almost the smallest cross-section of wire per ampere (column *z*). This higher efficiency is, however, obtained at the expense of the efficiency of the field, as will be seen from column *r*. The useful commercial efficiency of the whole machine is therefore below the average, as seen from column *D*. Next to this armature, in point of efficiency as an inductor, is the largest one, Edison No. 20. Its high efficiency is no doubt due to the great intensity of field (column *o*), the very small amount of wire on the armature (column *t*), the relatively high inductor velocity (column *e*), the large proportion of active wire (column *r*), and the comparatively small cross-section of the wire, per ampere (column *z*). The field of this machine has next to the highest efficiency as seen in column *r*, and therefore, as might be inferred, the machine has the best useful commercial efficiency of all of those tested, as seen in column *D*. It may be interesting to mention here that in this machine which has the best efficiency, the armature wires cut the field less frequently than in any other, as seen from the number of turns in column *h*.

Another proportion which may serve as a guide in designing armatures, is the relation between the outside diameter of the armature and the diameter of the core, or what amounts to the same thing, the percentage of the external diameter which is taken up by the wire on both sides. These figures are given in column *F*, and are obtained by dividing twice the depth of the windings given in column *E* by the external diameter in column *a*. This is greatest in the smallest armature, Edison No. 4, showing another disadvantage of small armatures; it is least, and therefore best, in the Weston 6 M, which may partially account for the economic field shown in column *r*, as the latter depends on this non-magnetic space.

A few other proportions may be deducted from the data given. One of these is the proportion of the distance between the pole-piece projections and the distance between the pole-pieces and the armature core. This proportion should evidently be as great as practicable. The figures are given in column *G*, and are obtained from columns *i* and *E*, allowing about $\frac{1}{16}$ of an inch for clearance on each side. It is greatest for the largest machine, Edison No. 20, which may partially account for its economic field in column *r*. The reciprocals of one-half of the numbers in column *G* may be said to represent approximately the intensity of the leakage of magnetism, as compared to the intensity of the useful field at these places, as the lines of force have the choice of these two paths. But this will be only a rough approximation, as a field is always more intense at points or sharp edges.

Another useful proportion is the relation between the length and diameter of the armature core, as deduced from columns *k* and *b*. It is given in column *H*, which shows by comparison with column *v* the advantage of a long armature. The Weston machines appear to be uniform in this respect, the length being almost twice the diameter.

Column *I* gives the relation between the length and diameter of the bearings.

Column *J* gives the electromotive force between two neighbouring commutator-bars. If this is great enough to maintain an arc across the insulation of the commutator-bars (about twenty volts) there is danger of starting the well-known flash, encircling the whole commutator, if the brushes should be misplaced sufficiently far to start the arc. It will be seen to be far within the limit of twenty volts in all of these machines.

The Edison Nos. 10 and 20 machines afford a good opportunity to compare two armatures of different lengths, but having all the other sizes and proportions alike, including the number of windings, size of wire, depth of winding, &c., only that in the one three wires are connected in parallel, and in the other, two; and that in the No. 20 the distance between the pole-piece projections is greater, making a difference of about 10 per cent. in the number of active wires in favour of the smaller one. The chief gain of the long armature is seen in column *r*, in which it has the highest percentage, which partially accounts for the efficiency in column *C*, and the consequent commercial efficiency in column *D*.

The subject of self-induction of the armature was purposely omitted here, partly because insufficient data are given in the report to make any practical deductions regarding it, but principally because it is presumed that the self-induction in such armatures as these, with very few turns, is so small that it may be neglected in such rough values as have been deduced here. It is to be regretted that the resistance of the field-coils without the regulator-box was not measured in each case in order that the effect of the self-induction of the field-coils in increasing the apparent resistance could be calculated, and its relation to the number of pulsations or commutator-segments determined. In only one case was the field-resistance measured alone, and from this a calculation shows an increase of resistance of less than one-tenth of 1 per cent., and, therefore, probably less than the allowable error in measurement.

The fact that the Edison Nos. 5 and 20 machines gave way in the armature insulation will not lessen the value of these deductions to the designer of dynamos, as this was presumably a defect in the details of construction, and not in the proportion of parts.

The test of the Edison No. 20 machine was marked unofficial in the report because the preliminary run of ten hours was not on full load; but it is no doubt sufficiently accurate for the deductions of the approximate values of the table.

The deductions here made are not for the purpose of comparing the commercial value of these machines, as it has been shown in the tests that they are practically equal electrically. The most important consideration in this respect would be the cost of the machines and the cost of maintenance and attendance, which cannot be considered here.

For the benefit of any one not familiar with these machines, it may be added that they are all simple shunt machines, with cylinder armatures.

In conclusion, it may be said that the values deduced in the table may not be free from small errors, as great accuracy was not possible in all cases, owing to the want of some few detail dimensions; moreover, great accuracy has no particular value in such general deductions as these.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended January 14th amounted to £4,701.

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THE ELECTRICIAN.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XVII.

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CONTENTS.

Notes ... 227
Elementary Electricity and Magnetism—II. (Continued.) 232
Practical Deductions from the Franklin Institute Tests of Dynamos. (Concluded.) ... 233
RETROSPECT OF THE PAST YEAR (Continued.) Illustrated. ... 236
Correspondence ... 239
The Self-Induction and Resistance of Compound Conductors. By Lord Rayleigh, D.C.L. (Concluded.) Illus. 240
The Bentley-Knight Electric Railway System. Illustrated 240
Primary Batteries. By Sidney F. Walker ... 243
Vesey's Electric Laryngoscope. Illustrated ... 244
Society of Telegraph-Engineers and Electricians.—Presidential Address. (Concluded.)... 245
Companies' Meetings—
The Eastern Telegraph Company ... 247
Companies' Share List ... 248

1886.

II.—LAND TELEGRAPHS.

The telegraphic system being in the hands of the State, there is no record to be made of competition. The surprising increase of traffic which has been uninterruptedly going on since the adoption of the Sixpenny Tariff for inland telegrams is so regularly recorded in non-scientific newspapers that we need not reproduce the figures here. Suffice it to say that the result of this great reform has exceeded the most sanguine expectations, both as regards the number of messages dealt with and the revenue derived therefrom. The public on their part have not less reason to be satisfied with the manner in which this vast addition to the work of the Postal Telegraph Department has been performed. For a time there was considerable grumbling at the extra trouble imposed upon the senders of telegrams in regard to their addresses; but this was only for a time, and there has been a singular absence of complaint on the score of delay or diminished speed of transmission. If silence may be taken for content in this relation—and the public are not remarkable for patience or reticence where a State Department is concerned—we may infer that the heavy traffic under the new regulations, now approaching double what it was under the old, is disposed of as expeditiously and as correctly as was the comparatively light traffic when the shilling rate prevailed.

Improvements which have been made in the electrical appliances of the Department seem to justify the statement that this is actually the case. Increasing the number of wires would, of course, contribute to this end; and so complete were the preparations in this respect before the alteration of the tariff was effected, that no very considerable addition to the wire accommodation appears to have been required or made during the past year. To keep pace with the ever-increasing work, improvements in the apparatus have been relied upon; and these, it is needless to say, are the objects of unremitting attention at the hands of the departmental electricians. But for the scientific knowledge, mechanical ingenuity, and practical experience brought to bear upon its electrical appliances by the officers of this important department, under the supervision of Mr. W. H. Preece, the present requirements of the service probably would have to be met by a large augmentation of operators and wires. The improvements in the Wheatstone and Multiplex systems which we have seen at work in the Post Office, had they been devised and patented outside a Government department, might have made the fortunes of half a dozen private individuals, to say nothing of some entirely novel appliances which have been invented and perfected on the spot.

The Wheatstone transmitter is by far the most important apparatus employed for the telegraphs of this country; and nowhere else has its working capacity been so largely developed. The improvements it has undergone may be said to have almost transformed it into a new instrument. With condensers and rheostats its ordinary rate of working has latterly been increased from 200 to 350 words a minute; and some specially designed condensers and repeaters have added nearly 40 per cent. to the working capacity of the cables to which duplex Wheatstone apparatus is connected. To further extend the use of this valuable instrument a new form has been devised, which absorbs far less battery power than the patterns hitherto employed. The economy of batteries thus effected is of much importance, as these essential adjuncts of telegraphy, especially at the larger offices, were becoming almost unmanageable. Much attention has, therefore, been given of late to the grouping and arranging and general oversight of batteries, the effect of which has been to materially decrease their number, or, at all events, to retard their inordinate increase. The Delany system of telegraphy, which we described and illustrated in these pages May 7, 1886, has been on trial at the Post Office during the year, and already some valuable improvements have been made in its construction and method of working. A new tangent galvanometer has been introduced possessing great merits in points of novelty and simplicity [*v. Electrician* Vol. XVII., p. 431]; and that the general efficiency of the apparatus constructed by the Telegraph Department has been largely increased by reducing the thickness of the silk covering of the copper wire.

It will not be out of place here to make some reference to the telegraph system and underground wires. Were we to attempt to explain the errors into which the correspondents to the political papers continually fall, we should have no space left for other matters, and should probably be inmates of an asylum before six months had passed. It does seem a pity, however, that such excellent papers as *The Times, Standard, Telegraph,* and *Daily News* do not employ competent scientific writers to correct the mistakes and exaggerations of

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their correspondents. The general public is altogether misled by information which contains only a germ of truth; for example, from *The Times* correspondent in Germany we should gather that because underground wires are largely used in Germany they can be used here under the conditions that hold in sending messages. In the first place, we have this great difference. An Englishman who hands in a message at any telegraph office expects it to be sent before he gets to the door, and probably imagines he ought to get an answer before the door is closed. The German, however, if he requires expedition expects to pay for it, and if he does not pay for it the messages get away as business will allow. The fast-speed working, as we know it in England, is in advance of that of any Continental nation, and if the Englishman will have speed he cannot get the main portion of his telegraph wires underground. We have no objection to connecting the most important towns and the shore end of cables by underground wires, but these connections would form only an alternative route in case of urgent need.

While digressing from dynamos, we may take this opportunity of referring to the work of one or two of the large wire drawers and coverers.

WALTER T. GLOVER AND CO., Salford.—We are informed that this firm has carried out orders for cables for many important electric light installations during the past year, and have been busy on general wire and cable work. Their business has extended to most of the Continental countries and to many of the British dependencies. This is particularly the case as regards telephone and telegraph wire, of which they are extensive manufacturers. They have been paying special attention to non-inflammable flexible cords for incandescent lamp suspending, and have also done much in the same direction with ordinary leads and cables. They have also patented a new anti-induction telephone cable, which is reported to have given very good results. A change has been made in the constitution of the firm, by which Mr. Henry Edmunds has become a partner, and is conducting business at their new London address.

The firm of FELTEN AND GUILLEAUME have since our last report in 1885 been steadily employed in cables for telegraph, telephone, and electric light, also in iron and steel wire for telegraph and telephone lines, and bare copper wire for electrical purposes. Although no exceptionally large orders have been booked, still, during the past year, Messrs. Felten and Guilleaume have been kept well employed, and in their special anti-induction telephone cables further improvements have been made, and the cables which this firm supplied late in 1885 for Copenhagen, Berlin, Nuremberg, and the Mersey Tunnel have still continued to do excellent service. The Mersey Tunnel cable in particular has exceeded all expectations in regard to its efficiency and freedom from induction. These anti-induction cables are lead covered, and the conductors are insulated with a material the composition of which is known only to Messrs. Felten and Guilleaume, and which renders the cable impervious to all atmospheric influence—even the sun's most intense heat—and for hot climates these cables are said to be invaluable.

The anti-induction telephone cables, besides being employed in Europe, are also largely used in North and South America, and Messrs. Felten and Guilleaume have also executed orders for Australia.

V.—ELECTRIC LIGHTING.

The accompanying illustration, Fig. 22, shows a plan of the Ganz machine, which was fully described in our last issue. This illustration, in connection with those previously given, will enable readers to fully understand the most recent continental practice in the construction of dynamos.

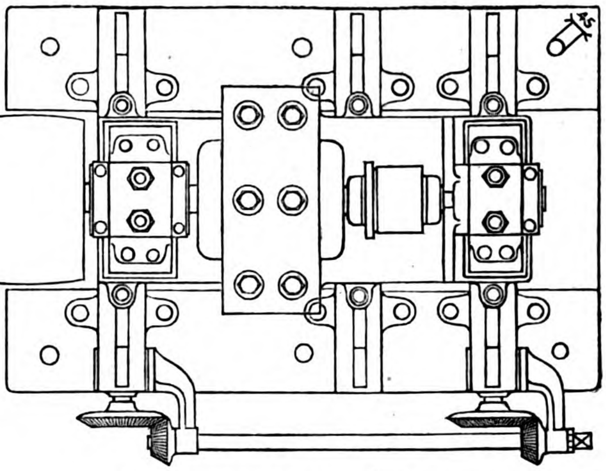

FIG. 22.—Plan of the Ganz Dynamo.

Messrs. GOOLDEN AND TROTTER have devoted a considerable amount of attention to the construction of dynamos, and have made a considerable number for ship-lighting to Government order, as well as for land work. The machine illustrated in Fig. 23 is a 16-unit machine, to be used at the Gaiety Theatre.

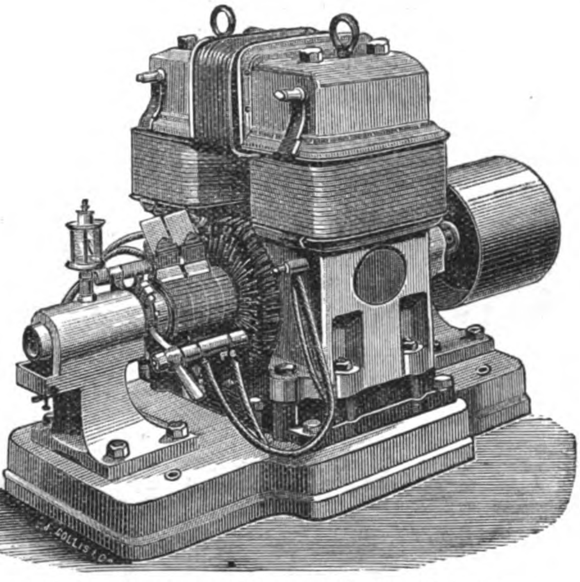

FIG. 23.—Goolden and Trotter G.T. Type Dynamo.

This machine has been compounded to specification for 53·5 volts at terminals on open circuit, and 56 volts with full load, to give 285 amperes at 765 revolutions. The horse-power required at this speed for the normal output is 24·1. The efficiency is given as 93 per cent. electrical, and 89 per cent. commercial. The size over all of this machine is 3ft. 2in. by 2ft. 2in. by 4ft., with a weight of about 2,580lbs. The weight of magnetised iron is 1,971lbs. The total weight of copper 230lbs. These figures give an output of 6·2 watts per lb. of machine, and 69·5 or 97·5 (at a speed of 3,000ft. per minute) per lb. of copper. The field-magnet is a single vertical magnet made of the best hammered scrap annealed, weighing 1,708lbs. The series coils of the field-magnets are wound with 48·8ft. of wire tape ·5 by ·1, four in parallel, the tape having a sectional area of ·2 sq. in., and the coil a resistance as connected of ·002 ohm, taking a current of 285 amperes, with 13 turns, or having 3,700 ampere turns. The number of watts lost in these coils is given as 162, and the current density 1,420 amperes

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per square inch. Total ampere turns in series and shunt coils is 13,700, and the total watts lost 585. The shunt coils have a length of wire 6,390ft. No. 13 S.W.G.; diameter ·092in., with sectional area ·0066 sq. in., having a resistance as connected of 7·3 ohms, with 1,410 turns, taking 7·66 amperes. The ampere-turns are 10,000, and the watts lost 425. The current density is 1,160 amperes per square inch.

The armature of this machine is of the ring type, and is composed of discs of charcoal iron ·036in. thick, with paper insulation between the discs. The armature is supported on phosphor bronze spiders and insulated from them. The length of wire in series is 220ft., the total length on armature being 220 × 2 = 440ft., there being two No. 6 B.W.G., ·203 diameter in parallel, having a total weight of 55lb. The resistance is ·00725 ohms; current density, 2,220 amperes per square inch; watts lost, 619; two circuits between brushes. The weight of iron in armature is 263lb. These figures give 291 watts per lb. of copper, and ·805 volt per yard of conductor. The strength of magnetic field is given as 10·2, clearance of armature $\frac{3}{32}$in. The difference between the outside diameter of the armature core and field space between the pole-pieces is $\frac{7}{8}$in. The peripheral speed of armature at the normal velocity is 2,140ft. per minute, running by a steel shaft, $1\frac{7}{8}$in. diameter, in phosphor bronze journals. Journal $\frac{\text{length}}{\text{diameter}} = 4·54$. The brushes, two on each side, consist of 37 strips No. 30 sheet copper, and are arranged with angular, circular, and pressure adjustment. The number of pieces in the commutator is 80, and the driving pulley has a diameter of 14in. and a breadth of 11in.

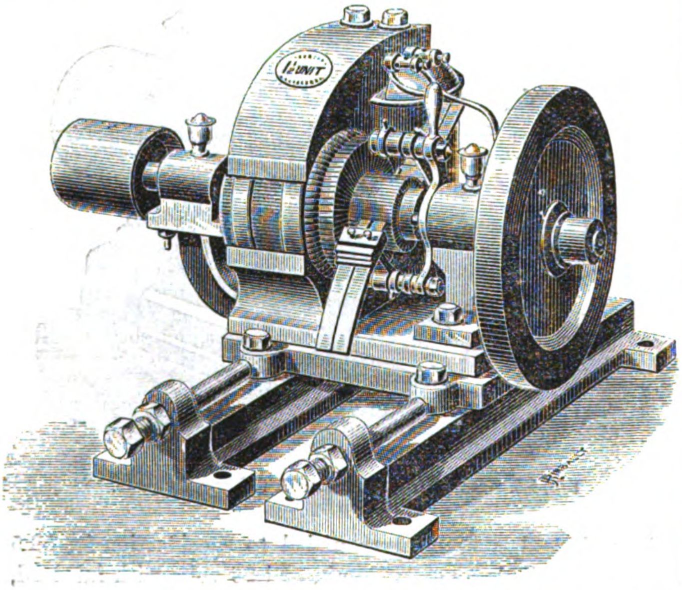

Fig. 24.—Goolden and Trotter M Type Dynamo.

We have said previously that this machine was built to specification, and differs in a few details from the ordinary pattern built by the firm. Thus, the commutator pieces are usually 120, but here, the volts being low, the number was reduced to 80, and would have been fewer still but that a less number meant drawing a small quantity to a special angle, while those used are such as are commonly in stock. The usual speed, again, is 3,000ft. per minute. It is interesting to be able to give these figures of a machine built to specification, with modifications from the usual type. This firm builds three types of machine, respectively known as the G. T., or Gramme type, the A, or Admiralty type, the M, or motor type.

Fig. 24 shows the new type M, or motor type, introduced last year. The machine shown is of $1\frac{1}{2}$-unit output, at a speed of 1,500 revolutions. The special point is the use of the single magnet bar at the back. The general proportions are the same as in the other machines made by Messrs. Goolden and Trotter. The height is 1ft. 7in., and the machine takes about 3 horse-power to drive it at the above output, and yields $1\frac{1}{2}$ horse-power as a motor.

Among the electrical firms who have introduced a dynamo of their own design for the first time during the year are Messrs. J. H. Holmes and Co., of Newcastle-on-Tyne. The "Castle" dynamo, as it is to be called, is illustrated in Fig. 25, from which it will be seen that it is built upon the general

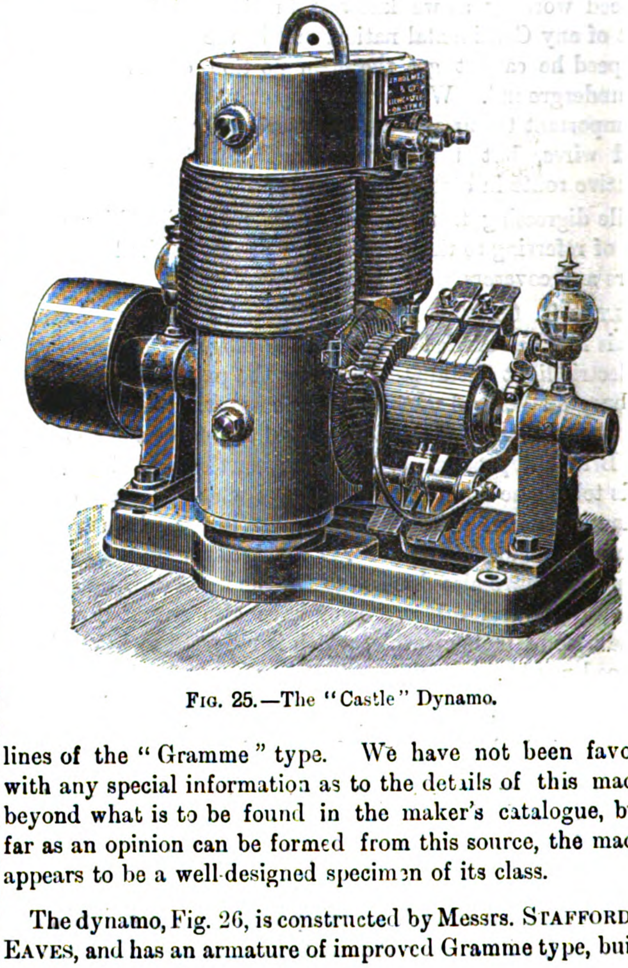

Fig. 25.—The "Castle" Dynamo.

lines of the "Gramme" type. We have not been favoured with any special information as to the details of this machine beyond what is to be found in the maker's catalogue, but so far as an opinion can be formed from this source, the machine appears to be a well-designed specimen of its class.

The dynamo, Fig. 26, is constructed by Messrs. Stafford and Eaves, and has an armature of improved Gramme type, built up

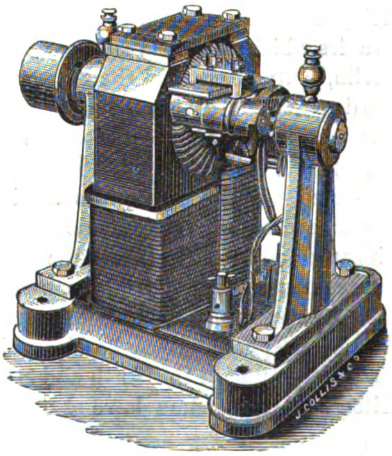

Fig. 26.—Stafford and Eaves Dynamo.

of discs of charcoal sheet iron, specially annealed, mounted on a gun-metal spider, and wound with one layer of wire. The field-magnets are of the single horseshoe type, the limbs being

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made from hammered scraps carefully annealed, mounted on a solid cast-iron base plate, which, at the same time, serves as the yoke. The commutator is of the ordinary type, the bars being cast in an alloy of seven parts copper to one of tin. The bearings are made with solid gun-metal bushes, having a length equal to four times the diameter of the shaft. The figures relating to this machine, although sent us, are not now given, inasmuch as we understand slight modifications are being introduced in the machine.

CORRESPONDENCE.

STORAGE BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As Mr. Davis, the secretary of the Primary Battery Company (writing, apparently, on behalf of that company and of the Union), arrogates to himself the function of a court of law, declaring invalid the patents of the Electrical Power Storage Company, and asserting that the manufactures of the companies in which he is interested are no infringements, I must leave him to the enjoyment of his own convictions.

I will only suggest to those interested in the matter that they should look at my patent specification No. 5631, 1881, and at those of Messrs. Fitzgerald and Jones. Nos. 15,777, 1884, and 5045, 1885, the property, I understand, of the Union Company, and form their own conclusions.—Yours, &c.,

JOHN S. SELLON.

MR. KAPP'S FORMULÆ FOR DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I gather from Mr. Kapp's remarks at the "S. T. E. and E.," during the discussion of his paper on dynamos, that he considers the wire on the outside of a field-magnet of the ordinary horseshoe type as practically wasted, since it cannot produce lines of force through the armature, but only "leakage lines" from pole to pole through the air. If this conclusion is correct, does it not make his formula for the total number of magnetic lines obtainable *per ampere-turn* incorrect when applied to a field-magnet of the "ironclad" type, such as that in Prof. Forbes's disc dynamo, since in this case we get just double the number of lines per amp.-turn? In other words, what we really get effect from, with the single horseshoe type, are only *half ampere-turns*, instead of amp.-turns.

If Mr. Kapp or any of your readers would enlighten me on this point I should feel much obliged, as it makes a very great difference in designing a dynamo.—Yours, &c, A. T.

CARBON FILAMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in Mr. Swinburne's papers on "Incandescent Lamps," now appearing in your journal, the statement that some filaments prepared from the tufts of fibrous carbon found in coke ovens have been submitted to him, but that, owing to their irregular form, he has been unable to use them.

I do not here wish to express any opinion as to the suitability of this variety of carbon for the purpose in question, but, assuming the irregularity of form to be the only objection to its use, I would, with your permission, point out a better method of manufacture than the heating of coal.

It is, I think, not generally known that in 1826 Dr. Hugh Colquhoun, while experimenting in connection with Macintosh's process for the conversion of iron into steel by the action upon it of carburetted hydrogen gas at a high temperature, obtained a very perfect form of tufted carbon. He states that opening one day the steel chest in which the conversion was effected he discovered "lying irregularly in various parts of it a quantity of long capillary threads of carbon, lustrous, and slender, each portion collected into a small bunch, as it were, of parallel lines, and in form extremely similar to a tress of fine hair. A single lock of this *mineral hair* seemed to contain thousands of these fine filaments. There was nothing to which this new form of aggregation of carbon could be better compared than a bunch of fine glass spun hair, or a tuft of one of the most perfect varieties of asbestos. The hairs in point of length had a range of from an inch, or even less, to eight inches. In thickness some of them might equal a hair from a horse's mane, while others were as delicate as the filaments of the lightest spider web. The colour of the whole was always black, and the lustre invariably bright and metallic."

He states that the filamentous carbon obtained in the coking process "is decidedly inferior in every characteristic to that which occurs in the steelifying process. It is smaller in quantity, its fibres are short, curled, and confusedly interlaced among each other; it is also generally without lustre, and is, therefore, very different from the long, parallel, and slender filaments of the more perfect formation."

Colquhoun was only occasionally successful in obtaining his filaments, for in his day the conditions of success in the operation were not known. His paper will be found in "Thomson's Annals of Philosophy," new series, Vol. XII., pp. 1—13, July, 1826.—Yours, &c., ALFRED W. SOWARD.

CUTTRISS' SIPHON VIBRATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having observed a letter referring to my "Siphon Vibrator" in your issue of December 10th last, I trust you will accord me some of your valuable space in my endeavour to correct any misapprehensions which may have been produced in the minds of your readers who may have read the letter in question and its addendum.

Without noticing the flippancy and personality of certain remarks contained in the letter mentioned further than to express the opinion that they are entirely out of place in scientific discussions, I would say that during the year 1876 I made a series of experiments on vibrating siphons by magnetism, and by that means obtained very fair results. One method employed was that of rocking the siphon in a pivoted cradle, using a make and break similar to that of an induction coil as the motive power; but as I had previously introduced, and, I might add, was the originator of the small recorder in which the siphon is fastened directly to the signal coil, which worked with rapidity and entire satisfaction, it was not considered advisable to complicate it with any vibrating attachment.

Having thus overcome the troubles attendant upon the use of electrified ink, I did not realise the value of a mechanical vibrator on a long cable recorder where electrification was still necessary until 1884, when once more I had charge of one. I then proceeded to construct one of my old vibrators, but quickly realised that in order to obtain a *perfectly straight and steady line* with the siphon hanging free and unrestrained laterally, as in a Mouse-Mill recorder, the vibrating force must be applied directly to its free end. This necessitated the invention of a vibrator or interrupter capable of fine adjustment and continued regularity of action, while at the same time allowing of its rate of vibration being readily changed to suit any siphon. The instrument under discussion attains the desired end in the simplest manner, and until proof to the contrary is produced I shall continue to claim and defend its originality.

In regard to its adaptation to the Mouse-Mill type of recorder, my critic should be more cautious in attacking in a scientific journal an instrument of which he has evidently but slight knowledge, the practical working of which has been watched, and its results acknowledged to be far superior to those obtained by his method by parties who are familiar and satisfied with his results. If delicacy of adjustment is not necessary on an Atlantic cable of 2,400 knots, there are, indeed, few cases in which it is. Yet, over the Commercial Cable Company's cables of this length, by means of the instrument in question, 23 to 25 five-letter words per minute, of good legible signals, are constantly being recorded.

As to the statement that there are many ways of obtaining this end by means of a vibrator, I can only say that when my critic can produce a perfectly straight and regular dotted

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line at the rate of from 80 to 100 dots per second, with a freely suspended siphon (80 being the minimum permissible for good clear signals at a quick rate over a long cable) by any other means than by electrified ink or my method, I will acknowledge the truth of his statement; until then I am obliged to doubt it.—Yours, &c., CHAS. CUTTRISS.

21, Wall-street, New York, January 1st, 1887.

THE BENTLEY-KNIGHT ELECTRIC RAILWAY SYSTEM.

One more electric railway system is to be tried in New York, where powers have been obtained for a circular line traversing an important district, which is to be built and equipped upon a system known under the name of Bentley-Knight. This is one of the central conduit systems, and it is interesting chiefly on account of the details of the construction of the conduit and the traveller which we describe and illustrate below. We need say nothing as to the electrical arrangements further than that the motor is described as a "modified Gramme," and that the power is varied by switching resistances in and out of circuit. If the conduit arrangements prove to be successful, the electrical details will no doubt be found to be readily susceptible of improvement. As to the gearing we have no very complete information. It is described by the *Electrical World* of New York in the following terms:—"The motor has a pair of pinions keyed to the ends of the armature shaft, which work with gears mounted on a crank shaft in the centre of the car. Connecting rods on each side transmit the motion from the crank shaft to the driving wheels." The conduit is illustrated in Fig. 1; its construction

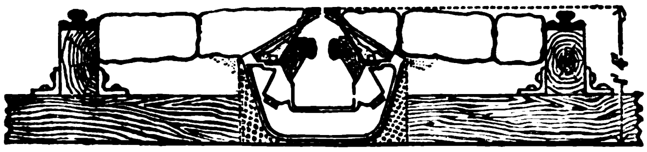

FIG. 1.

is described in the same journal as follows:—"The iron yokes are first set up and lined, being placed from 3ft. to 4ft. apart, and between the ties which support the rails. The continuous concrete gutter is then formed, the material being rammed around and between the yokes with the aid of wooden forms fitting the yokes. The insulating pins are then placed in the sockets cast in the yokes, and the conductors, in lengths of 30ft, are set against the pins and firmly keyed to them. The electrical connections between the lengths of conductor are then made, and the slot irons set on the yokes, their stay bolts dropped into the exterior lugs of the yoke, and the slot irons and yokes firmly bolted together, leaving a surface opening of only ⅝ of an inch. The two main conductors consist of channel iron, connected by expansion joints and lined with a continuous strip of copper of sufficient size to carry the current with but small loss of energy. These conductors are fastened to the side walls of the conduit on insulators of vulcanised wood dipped in white lead. The insulators are strongly set in sockets in the cast-iron supporting yokes. Neither the traffic rails nor the conduit structure form any part of the electrical circuit. To provide for switching a movable tongue is pivoted at the point of branching, so as to rest on the top of the conduit and to be readily set to close either of the branch slots, and direct the contact plow into the other. A corresponding conductor tongue within the conduit is moved at the same time.

"The method of making electrical connection between the motor and the conductors in the conduit—an important point—has been well worked out, and is clearly shown in Figs. 2 and 3. For this purpose a contact-plow is employed, which consists of a flat frame, I, hung from the car by transverse guides, P, on which it is free to slide the whole width of the car and extending thence down through the slot of the conduit. It is provided with a swivel joint, Q, so as to adjust itself to all inequalities of road or conduit. This frame carries two flat steel insulated conductor cores, K, to the lower ends of which are attached by a spring hinge small contact shoes, H, of chilled cast iron, that slide along in contact with the two main conductors C. At the upper ends are flexible connections leading to the motor. This plow can be inserted or withdrawn through the slot at will, the spring hinge allowing the contact shoes to straighten out into line with the conductor cores when the plow is pulled upward and the shoes strike the insulating lining with which the slot irons are provided. By no accident, therefore, can anything be left behind in the conduit to obstruct succeeding cars. The plow guides are hung on transverse axes, and are held in a vertical position by a spring-catch that gives way when the plow meets an irresistible obstruction, and hence the plow is automatically thrown completely out of the conduit without injury, being almost immediately replaceable. The contact shoes will stand weeks of wear and cost next to nothing. The frame of the plow has wearing guards, I, of hardened steel wherever it can touch the edge of the conduit slot, and these are also readily renewed. Two plows are used on each contact for the sake of absolute reliability, and to prevent flashing at the contact.

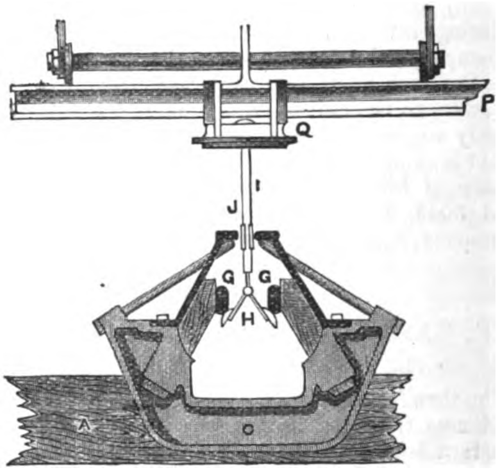

FIG. 2.

"The road is to be a double track, the greatest grade being 1 in 12. The estimated cost of the line is as follows:—12,660ft. conduit (extra heavy), at $4, $50,640; 20 motor trucks complete, at $1,200, $24,000; six 50 horse-power

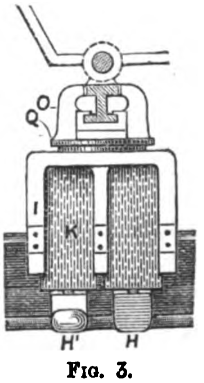

FIG. 3.

dynamos, at $2,500, $15,000; steam plant complete, $20,000; foundation, $2,000; engineering, $2,500; total, $114,140."

THE SELF-INDUCTION AND RESISTANCE OF COMPOUND CONDUCTORS.

BY LORD RAYLEIGH, D.C.L.

(Concluded from page 223).

In the Wheatstone quadrilateral, as arranged for these experiments, the adjacent sides R, S are made of similar wires of German silver of equal resistance (½ ohm). Being doubled they give rise to little induction, but the accuracy of the method is independent of this circumstance. The side P includes the conductor, or combination of conductors,

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under examination, an induction-compensator, and the resistance-slide. The other side Q must possess resistance and self-induction greater than any of the conductors to be compared, but need not be susceptible of ready and measurable variations. But, as a matter of fact, the second induction-compensator was used in this branch, and gave certain advantages in respect of convenience. Sometimes also a rheostat was included; but during a set of comparisons the condition of this branch was usually maintained constant, the necessary variations being made in P. In order to avoid mutual induction between the branches, P and Q were placed at some distance away, being connected with the rest of the apparatus by leads of doubled wire.

It will be evident that when the interrupter acts in the battery branch, balance can be obtained at the telephone in the bridge only under the conditions that both the aggregate self-induction and resistance in P are equal to the corresponding quantities in Q. Hence when one conductor is substituted for another in P, the alterations demanded at the compensator and in the slide give respectively the changes of self-induction and of resistance.

In this arrangement the induction and resistance are well separated, so that the results can be interpreted without calculation. During the month of July a large number of observations on various combinations of conductors were effected, but the results were not wholly satisfactory. There seemed to be some uncertainty in the determination of resistance, due to the inclusion of the two movable contacts of the resistance-slide in one of the sides (P) of the quadrilateral.* I therefore pass on to describe a slight modification by means of which much sharper measurements were attainable.

In order to get rid of the objectionable movable contacts, some sacrifice of theoretical simplicity seems unavoidable. We can no longer keep Q (and therefore P when a balance is attained) constant; but by reverting to the arrangement adopted in a well-known form of Wheatstone bridge, we cause the resistances taken from P to be added to Q, and *vice versâ*. The transferable resistance is that of a straight wire of German silver, with which one telephone terminal makes contact at a point whose position is read off on a divided scale. Any uncertainty in the resistance of *this* contact does not influence the measurements.

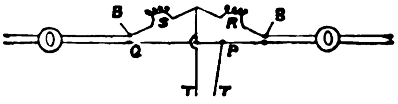

FIG. 1.

The diagram shows the connection of the parts. One of the telephone terminals goes to the junction of the ($\frac{1}{2}$ ohm) resistances R and S, the other to a point upon the divided wire. The branch P includes one compensator (with coils connected in series), the subject of examination, and part of the divided wire. The branch Q includes the second compensator (replaceable by a simple coil possessing suitable self-induction), a rheostat, or any resistance roughly adjustable from time to time, and the remainder of the divided wire. The battery branch, in which may also be included the interrupter, has its terminals connected, one to the junction of P and R, the other to the junction of Q and S. When it is desired to use steady currents, the telephone can of course be replaced by a galvanometer.

In this arrangement, as in the other, balance requires that the branches P and Q be similar in respect both of self-induction and of resistance. The changes in induction due to a shift in the movable contact may usually be disregarded, and thus any alteration in the subject (included in P) is measured by the rotation necessitated at the compensator. As for the resistance, it is evident that (R and S being equal) the value of any additional conductor interposed in P is measured by twice the displacement of the sliding contact necessary to regain the balance.

The position of the contact was read to tenths of an inch; and, since the actual resistance per inch was ·0246 ohm, a displacement of that amount represents ·0492 ohm. To save unnecessary reductions, the resistance of any conductor will usually be expressed in terms of the contact displacement caused by its introduction, just as the self-induction is expressed in degrees of the compensator.

In order to compare the behaviour of iron and copper, two double coils were prepared as nearly similar as conveniently could be. The iron coil was that already spoken of. The resistance of each wire was ·9 ohm, and the diameter ·032in. In the double copper coil the resistance of each wire was ·1 ohm, and the diameter ·037in. Each coil consisted of 9 (double) convolutions, of diameter about $4\frac{1}{2}$in.

The two iron wires being connected in series, the large self-induction (when the current circulated the same way in both wires) was found to be 65°·1; the small self-induction (when the directions of circulation were different) was 23°·1. On the other hand, with the copper wires the large self-induction was 45°·0, and the small only 1°·0. Thus, although the manner of connection makes far more *relative* difference in the case of copper than in the case of iron, the absolute difference, which represents four times the mutual induction of the two wires, is nearly the same, viz. 44°·0 for copper and 42°·0 for iron. There is here no evidence of any distinction in the mutual induction of iron and copper, the slight want of agreement being easily attributable to different degrees of closeness of approach in the two cases. The readings for resistance were sensibly the same, whether the currents were steady (balance being tested by a galvanometer), or were variable with a frequency of 1,050 per second. They were also unaffected by the reversal of one of the wires.

With the same pair of double coils an interesting experiment may be made by observing the effect of closing the second wire upon the apparent resistance and self-induction of the first. To steady currents the resistance of one of the copper wires was 1·75, unaltered by closing the circuit of the other wire. With secondary open, the same resistance was found to apply to periodic currents of frequency 1050; but when the secondary was closed the resistance rose to 2·67. On the other hand, the closing of the secondary reduced the self-induction from 11°·2 to 4°·7. It will be instructive to compare these results with Maxwell's formulæ:—

$$R' = R + \frac{p^2 M^2 S}{S^2 + p^2 N^2}; \quad . \quad . \quad . \quad . \quad (3)$$

$$L' = L - \frac{p^2 M^2 N}{S^2 + p^2 N^2}; \quad . \quad . \quad . \quad . \quad (4)$$

which we may do by means of a value of M (the mutual induction) deduced from the previous experiment, in which the wires were connected in series. Thus,

$$M = 11°\cdot0 = 11°\cdot0 \times 1553 \text{ centim.}$$

From the present experiment,

$$R = S = 1\cdot75 \text{ inches of slide} = 1\cdot75 \times \cdot0492 \times 10^9 \frac{\text{centim}}{\text{sec.}};$$

$$L = N = 11°2 \text{ of compensator} = 11\cdot2 \times 1553 \text{ centim.},$$

$$p = 2\pi \times 1050;$$

so that

$$\frac{p^2 M^2}{R^2 + p^2 L^2} = \cdot60.$$

Thus, according to the formulæ, the resistance R′ to the periodic currents should be

$$R' = R + \cdot60\,R = 2\cdot80\text{in. of slide.}$$

This compares with the 2·7 actually found. In like manner

$$L' = L - \cdot60\,L = 4°\cdot5 \text{ of compensator,}$$

agreeing as well as could be expected with the observed value 4°·7.

Similar experiments were made on the double coil of iron wire. With secondary open, the resistance of one wire to steady currents was 16·79. To periodic currents of frequency 1050 the resistance was just perceptibly greater, viz., 16·85, which increased a little further (17·15) when the secondary was closed. The closing of the secondary left the self-induction sensibly unaffected at 21°·2. The much slighter influence of the secondary here observed is due mainly to the higher

* Prof. Hughes appears also to have met with this difficulty in his second apparatus.

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resistance of the iron as compared with copper. A calculation carried out as before gives

$$\frac{p^2 M^2}{R^2 + p^2 L^2} = \cdot 016,$$

agreeing pretty well with the proportional change observed in the resistance. The corresponding change in self-induction would be barely sensible.

In the case where the primary and secondary circuits are similar (S = R, N = L), Maxwell's general formulæ may be written in the form

$$\frac{R' - R}{R} = \frac{L - L'}{L} = \frac{p^2 M^2}{R^2 + p^2 L^2}; \quad . \quad . \quad . \quad . \quad (5)$$

and we may note two extreme cases. When p is small, or, more fully expressed, when the period of vibration is long in comparison with the time-constant of either circuit, viz., L/R, the reaction of the secondary currents is of small importance. On the other hand, when p is large, the right-hand member of (5) approaches to the form M^2/L^2; and this again does not differ much from unity when the two circuits consist of a double coil of non-magnetic wire. Under such circumstances the reaction of the secondary tends to destroy the self-induction and to double the resistance of the primary.

Being desirous of investigating an example approximating to the second extreme, I prepared a double coil of stouter wire than the preceding. The diameter was about ·08 inch, and the length of each wire was 318 inches. There were 20 (double) turns, so that the mean diameter of the coil, wound as compactly as possible, was about 5in. The resistance of each wire was about ·05 ohm.

The coefficient of mutual induction was determined by comparison of the self-induction (L) of one wire with that of the two wires connected oppositely in series, viz. (2L – 2M). In this way it appeared that

$$M = 43°{\cdot}1 = 43{\cdot}1 \times 1553 \text{ centim.}$$

The interrupter was the reed, of frequency 1050.

Observation showed that the closing of the secondary diminished the self-induction from 44°·4 to 3°·4. The resistance to steady currents was ·92in. The resistance to the periodic currents was ·97 with secondary open, and 1·74 with secondary closed.

Taking then

$$L = 44{\cdot}4 \times 1553 \text{ centim.}, \quad R = \cdot 97 \times \cdot 0492 \times 10^9 \frac{\text{centim.}}{\text{sec.}},$$

we get

$$\frac{p^2 M^2}{R^2 + p^2 L^2} = \frac{10^{17} \times 1{\cdot}951}{10^{17} \times \cdot 023 + 10^{17} \times 2{\cdot}071} = \cdot 932.$$

According to the formula, therefore,

$$L' = \cdot 068\, L = \cdot 068 \times 44{\cdot}4 = 3°{\cdot}0,$$

which is to be compared with the observed 3°·4.

The application of the formula to the calculation of R′ is somewhat embarrassed by the observed difference of resistances to steady and to periodic currents when the secondary was open, of which the theory takes no account. It is true that the difference is small, but it appeared to lie outside the limits of error of observation. It is not accounted for merely by the tendency of periodic currents to adhere to the outer parts of a conducting cylinder. If this observation stood alone, one would be inclined to attribute the discrepancy to some action, whether electro-magnetic or electro-static, of the neighbouring secondary, even though open; but, as we shall have occasion to notice, a similar tendency of the resistance to increase when periodic currents are substituted for steady ones is to be observed in cases where no such explanation is available. The effect, was, however, too small to be investigated further without some modification in the apparatus, or in the nature of the conductors submitted to examination.

If we take, as found for the periodic currents, R = ·97, we get

$$R' = 1{\cdot}93 \times \cdot 97 = 1{\cdot}87,$$

instead of 1·74 as observed. On the other hand, if we take R = ·92, we get

$$R' = 1{\cdot}93 \times \cdot 92 = 1{\cdot}77.$$

The next experiment was contrived to illustrate the behaviour under periodic currents of a system composed of two conductors connected in parallel. The general theoretical formula are given in a former paper*; but the more special case selected for experiment was one in which the mutual induction of the two conductors (M) and the self-induction of one of them (N) can be neglected. The formulæ for the resistance and self-induction of the combination then reduce to

$$R' = \frac{SR}{R+S}\left[1 + \frac{S}{R} \frac{p^2 L^2}{(R+S)^2 + p^2 L^2}\right], \quad . \quad . \quad (6)$$

$$L' = \frac{S^2 L}{(R+S)^2 + p^2 L^2}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

in which SR/(R + S) represents the resistance to steady currents ($p = 0$). The peculiar features of the arrangement are brought out most strongly by taking a case in which S (the resistance of the induction-less component) is great compared with R. It is then obvious that steady, or slowly alternating, currents flow mainly through R, and accordingly that the resistance and self-induction of the combination approximate to R and L respectively. Rapidly alternating currents, on the other hand, flow mainly through S, so that the resistance of the combination approximates to S, and the self-induction to zero. These common-sense conclusions are of course embodied in the formulæ.

The conductors combined in parallel were (1) the coil of stout copper (p. 483) with its two wires permanently connected in parallel so as to give maximum self-induction (L), and (2) a moderate length of somewhat fine brass wire. With steady currents the resistances were

$$R = \cdot 45, \quad S = 2{\cdot}29, \quad R_0' = \cdot 35.$$

It had been expected that the resistances R, S, of the separate conductors would have been sensibly the same whether tested by steady or by periodic currents; but the resistances in the latter case tended always to appear higher. Thus with the same reed as interrupter,

$$R = \cdot 52, \quad S = 2{\cdot}33, \quad L = 43°{\cdot}7, \quad N = \cdot 3°;$$

and for the combination,

$$R' = 2{\cdot}04, \quad L' = 3°{\cdot}0.$$

These results of observation illustrate satisfactorily the general behaviour of the combination to periodic currents of high frequency, and they agree fairly well with the formulæ. According to these, if we take the values of R and S as observed with periodic currents, we have

$$R' = 2{\cdot}16, \quad L' = 2°{\cdot}61.$$

The altered distribution of current under the influence of induction, and consequent increase of resistance, exemplified in the above examples, is an extreme case of what may happen to a sensible extent within a simple conducting cylinder, especially of iron, when the diameter is not very small in relation to the frequency of electrical vibration. In order to avoid magnetising the material of the conductor, the current tends to confine itself to the outer strata, in violation of the condition of minimum resistance.

The increased self-induction and resistance of an iron wire, due to its magnetic quality, are doubtless disadvantages from a telephonic point of view. If found serious they may be mitigated, as Prof. Hughes has shown, by the use of a standard wire, in which the circumferential magnetic circuits are interrupted. There has been some confusion, I think, in connection with the notion of "retardation." If we had the means of observing the passage of signals at various points of a long cable, we should find them not merely retarded (which would be of no consequence) as we recede from the sending end, but also attenuated. The amplitude of a periodic, *e. g.* telephonic, current sent into a cable becomes less and less as the distance increases. Nothing of the kind can happen in a well-insulated iron wire of negligible electrostatic capacity. Its resistance and self-induction may oppose the entrance of a current, but whatever current there is at any moment at the sending end of the wire must exist unimpaired throughout its whole extent.

I will now record a few experiments as to the effect of an iron core upon the apparent self induction and resistance of

* *Phil. Mag.*, May, 1866, formulæ (13), (14), p. 377.

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an encompassing helix. The wire was wound in one layer upon a glass tube; the total number of turns is 205, occupying a length of 28·6 centim. The length of the wires forming the cores was 24·1 centim. The results given are the differences of the readings obtained with and without the cores, so that the resistance and self-induction of the helix itself are not included. The interrupter was the same reed as in previous experiments.

A comparison was made of the effect of a solid iron wire 1·2 millim. in diameter and of two bundles of wires of similar iron (drawn from the same specimen) of equal aggregate section and weight. One bundle contained 7 wires, and another 17. The results were :—

	1 wire.	7 wires.	17 wires.
Resistance	1·3	0·3	0·2
Self-induction	13°	18°	18°

showing that when the wire was undivided the secondary currents developed in it increased the apparent resistance of the helix, and diminished the apparent self-induction.

A similar experiment was tried with a stouter wire, 3·3mm. in diameter. In the hard condition the self-induction due to this was $24\frac{1}{2}°$, and the resistance 3·8; numbers altered to $28\frac{1}{2}°$ and 4·4 respectively by softening with a spirit flame. The effect of a bundle of thirty-five soft wires of the same iron and of equal aggregate section was 84° of self-induction and 1·6 of resistance.*

There is nothing surprising in the conclusion, forced upon us by the observations, that the magnetic effects of iron rods 3·3 millim. in diameter are seriously complicated by the formation of induced internal electric currents. As I have shown on a former occasion,† the principal time-constant of a cylinder of radius a, specific resistance ρ, and permeability μ, is given by

$$\tau = \frac{4\pi\mu a^2}{(2{\cdot}404)^2\rho}.$$

This means that circumferential currents started and then left to themselves would occupy a time τ in sinking to e^{-1} of their initial magnitude. Whether the effects of such currents will be important or not depends upon the relative magnitudes of τ and of the period of the magnetic changes actually in progress. In the present case, with

$$\mu = 100, \qquad \rho = 9827, \qquad 2a = {\cdot}33,$$

the value of τ is about $\frac{1}{2000}$ of a second—that is, about *half* the period of the actual electrical vibration.

We have seen in several examples that the self-induction of a combination of conductors, being a function of the pitch, admits of an indefinite series of values; and the question suggests itself to which (if any) of these corresponds the value obtained by galvanometric observation of the transition from a state of things in which all the currents are zero to one in which they have steady values under the action of a constant electromotive force. In the ordinary theory of Maxwell's method for determining self-induction from the throw of the galvanometer-needle in a Wheatstone bridge (a resistance-balance having been already secured), the conductor under test is supposed to be simple. The general case of an arbitrary combination of conductors can only be treated by a general method. An investigation founded upon the equations of my former paper‡ shows that the result which would be obtained by Maxwell's method corresponds to the self-induction of the combination for *infinitely slow* vibrations.

We have supposed that the behaviour of the compound conductor is not influenced by electrostatic phenomena; otherwise the representation of the part of the electromotive force in the same phase as dC/dt as due merely to self-induction would be unnatural. So far as experiment is concerned, we have no means of distinguishing between an effect dependent upon dC/dt and one dependent upon $\int C\,dt$, for the phase of both is the same. We may contrast two extreme cases—(1) a simple conductor with resistance and self-induction, (2) a simple condenser with resisting leads. In the first case the electromotive force at the terminals is written

$$L\,.\,ipC + R\,.\,C\,;$$

in the second

$$-\mu'\,.\,ip^{-1}C + R\,.\,C,$$

where μ' represents the "stiffness" of the condenser. If we persisted in regarding the imaginary part in the second case as due to (negative) self-induction, we should have to face the fact that the coefficient becomes infinite as p diminishes without limit.

A number of combinations in which the induction of coils is balanced by condensers are considered by Chrystal in his valuable memoir on the differential telephone.*

* It may be worth while to remark that in these experiments no approach to a balance could be obtained when a scraping contact interrupter was used. With the reed there was complete silence, or at most a slight perception of the octave. The failure of the scraping contact is due, of course, to the mixed character of the vibration, and to the fact that the adjustments necessary for balance vary rapidly with pitch.

† Brit. Assoc. Report, 1882, p. 446.

‡ *Phil. Mag.*, May, 1886, p. 372.

* Edinburgh *Transactions*, 1879.

PRIMARY BATTERIES.

BY SIDNEY F. WALKER.

Primary batteries may be divided into two classes; those used for telegraphy, telephony, electric bells, &c., in which the current furnished and the work done are both very small indeed, and is measured, if at all, in milliamperes; and those which are used for electric lighting, heating, and motive power, where the current used is rarely less than one ampere, and may be as strong as you can construct your battery to deliver. The same qualities are required for each class of battery, but with the one we can be far more indulgent in construing those requirements than with the other. When the work actually done is very small, variations are comparatively unimportant. A variation of 5 per cent. in a current of one milliampere would be inapplicable, and in practice we only care to see that the apparatus works. With the other battery, however, a variation of even 5 per cent. might not be allowable under certain conditions, and we therefore have to demand very much greater perfection in every part. The qualities demanded in any primary battery which is to be practically successful are:—First, the highest possible E.M.F. between the terminals. This, to anyone who has but a small knowledge of the subject would appear to be self-evident. Everyone can see that if one cell has double the E.M.F. of another that cell is the better, since only half the number would be required for certain work. Yet this is by no means the most important feature in a battery. We can always make up for deficient E.M.F. by adding cells, while we may not be able so easily to compensate for other disadvantages. But how is this high E.M.F. to be obtained? The E.M.F. at the terminals of the cell is the resultant algebraical sum of all the actions that go on within the cell. It may be well to point out here that what we call electromotive force, and which we say is generated primarily by the consumption of zinc or some other metal, is merely a transformation of energy from one form to another, and that the chemical reactions which go on in a battery are merely actions *pro* and *con*, whereby energy is set free in one place and taken up in another. If at the end of the series any energy remains unabsorbed, and the conditions are favourable, it becomes apparent as electromotive force. If the conditions are unfavourable, it may appear wholly or in part as heat, or one of the other physical forces. The fact that a body exists as a gas implies that it has absorbed a certain amount of energy in the form of heat. If we succeed in liquefying it, we set free a portion of this heat. Similarly, when zinc combines with oxygen, chlorine, or the acid radical SO_4, energy is set free, which under the conditions present in a galvanic battery becomes E.M.F. But, in order that zinc may combine with the oxygen or chlorine that are usually contained in a liquid in which the zinc is immersed, it is necessary that the liquid shall be decomposed into its constituents, and new energy is absorbed. Similarly at the other end, the combination of hydrogen, or any metal that may be present, with oxygen, chlorine, or any other element placed there for that purpose is a source of energy, while the decomposition of the salt from which the element is abstracted is a tax. In order, therefore, to obtain a high E.M.F., we must seek such an arrangement in our battery that the energy set free by combination is as much as possible in excess of that absorbed by decomposition. But we must be careful in following out our series to see that we take account of every action that goes on, or our theoretical result will be erroneous. Perhaps the above will also help to explain why the E.M.F. of the same pair of metals may vary with different solutions.

Secondly, we require in all primary batteries, but particularly in those which furnish large currents, that their internal resistance shall be as small as possible. For batteries doing auxiliary work,

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such as telephone, signal, &c., this feature is not of such great importance, as it is often of advantage to have a resistance in the circuit to reduce the working current, and this may as well be in the battery as anywhere else ; provided the resistance is not produced, as it too often would be, by reducing the quantity of oxidising material in the neighbourhood of the negative plate, or by introducing artificial contrivances such as bad contacts, &c., that are likely to be a source of trouble. Leaving these special cases out, it is one of the conditions of the efficiency of any electrical apparatus that the work done in the generator itself shall be as small as possible in proportion to the work done outside ; and further, a high resistance will deprive us of the benefit of a large portion of our available E.M.F. in the external circuit. Suppose that we have a battery whose total initial E.M.F. is 50 volts, and whose total resistance between terminals is 1 ohm. If we take 10 amperes from it, the E.M.F. at terminals drops at once to 40 volts, so that if 50 volts is the E.M.F. we want, we have to add several more cells to make up for this charge, and we are wasting in our battery 100 watts, against 400 only that we get outside, or a loss of 20 per cent. And our troubles are not at an end if we get over this difficulty by adding cells, and if we do not mind the loss involved. Unless we always require to burn the full number of lights, or to use the full current, we shall be involved in this difficulty, that as we reduce the current, say, by turning out lights, the E.M.F. at the terminals of the battery and of the lamps will rise, and we must either run our lamps under power when all are on, or we shall be obliged to strain our lamps when we are only burning a part of them. Suppose, for instance, that we reduce the current to one ampere. The E.M.F. rises at once to 49 volts, or nearly 25 per cent. above what we are working at, a strain which, if only maintained for a few minutes, might take hundreds of hours out of the life of the lamp. If the battery resistance had been 7 ohms, instead of 1 ohm, the variation between 1 ampere and 10 amperes would have been only 1 volt, or $2\frac{1}{2}$ per cent., which would be inappreciable. And how is this low resistance to be obtained? In order to know this we require to go into the construction of the cell, and to follow the current in its passage through it. Generated at the zinc plate, it passes through the liquids and their separator (if there is one) to the negative plate, and thence by the connecting wire, &c., to the zinc of the next cell. Clearly, in order that the whole resistance may be low, that of all its parts must be so, too. We must choose, if we can, liquids which have a low specific resistance, and if, as in most batteries, there is a porous division, it must be as porous as possible consistent with a fair life, and due separation of solutions. We must have very good connection between the zinc of one cell and the carbon of another, and of course to the terminal plates of the battery ; and it must be remembered that a connection that will answer well for a small current will not do for a large one.

A comparatively small contact surface will offer no appreciable resistance to the passage of a telephone current ; but if used for lighting work you will have heating, and possibly sparking, both of which will increase your troubles. The resistance of the plates themselves forms usually a very small part of the total resistance of the battery. The cross-section of the liquid must be as large as possible, and the distance between the plates as small as possible. This object is attained by making the plates large, and by so constructing your cells that they—the plates—are close together. A flat cell, with two zinc plates, enclosing a carbon plate, sandwich fashion ; and a round cell, in which the zinc is a cylinder, closely embracing, but not touching the porous pot, while the carbon inside the latter is very little less in diameter, fulfil these conditions. In the Leclanché and similar cells, of course, the mixture of carbon and manganese with the carbon plates completely fills the porous cell. It may be remarked here, however, that the loose agglomeration of carbon and manganese offers a comparatively high resistance ; in fact, a prohibitive resistance, unless there is a liquid conducting communication established with every granule. Until this is accomplished the filled porous cell presents merely a series of loose contacts, with their attendant troubles. Forms of this battery have been brought out from time to time, in which the carbon cell has been the outer one, the zinc being within the porous pot. The disadvantage of this is that you cannot change your carbon cell without considerable trouble, and meanwhile all that is attained can be equally as well and at less cost by using a larger complete cell. Next, the current given must be constant, under the same conditions. No condition is so important as this. E.M.F. may be low, resistance high within certain limits, yet if the current furnished be constant, the cell will be a far better one for practical work than another which has the advantages of high E.M.F. and low resistance, but which is not constant. That is, if a battery is put to do certain work it must do it as long as it is required. In practice, however, this means something very different when applied to small currents, and to electric light or other heavy work. With a small current, if the work required is to ring a bell, to transmit speech, or to move a magnetic needle, we are quite satisfied so long as it rings the bell or moves the needle, &c., though the current passing may and does vary from day to day, or even within a few minutes. With batteries furnishing electric light, however, it is quite different. Here both E.M.F. and resistance of battery must remain the same within certain very narrow limits during the whole time it is in use. With electric lighting by means of glow lamps this is especially important, and for this reason. The resistance of the incandescent lamp varies, as is well known. The current heats it, its resistance falls, and more current passes, and *vice versâ* ; consequently, if the E.M.F. of supply rises you have not only the increased light due to the increased current from the higher E.M.F., but also that due to the consequent lowering of the resistance of the filament, so that a comparatively small rise or fall may be unpleasant. And how is this constancy to be obtained?

The solution of this part of the problem necessitates a further reference to the working of the battery. We have, first, a plate of zinc, or some other metal, immersed in some solution containing oxygen, sulphuric acid, chlorine, or some element for which the metal has an affinity. When the current passes they combine, and, assuming zinc to be the metal, you have zinc oxide, chloride, or sulphate formed *on its own surface*. Now you have immediately a new set of conditions ; you have, by the action of the current, formed a new galvanic battery, consisting of the zinc, its salt, and the liquid in which the zinc is immersed. This cell, too, is one whose circuit is always closed ; and as long as the newly-formed salt remains on the plate you will have your zinc uselessly consumed by the action of this local battery, and also an added resistance more or less uncertain. It is necessary, therefore, that this salt shall be removed as soon as it is formed, and, as solution is the easiest method of accomplishing this, the liquid in which the zinc is immersed should be one that will readily and quickly dissolve the salt which one of its components forms with the generating plate. Such a condition is fulfilled when the zinc stands in a solution of its own chloride or sulphate, or in some solution which will dissolve them, such as the ammonium chloride in the Leclanché cell. The action described above, of the salt on its own metal, is termed local action.

It may be pointed out in connection with this point that the directions for the Leclanché cell so often given, viz. : that only sufficient sal-ammoniac to form a semi-saturated solution should be allowed, are wrong in practice. The cell works best with a saturated solution, and though it might save sal-ammoniac to wash out the cell whenever it has used up its charge, in practice it is not economical, as you can never tell whether you may not be throwing away good sal-ammoniac, and, in addition, the labour involved in washing the cell out is worth, as a rule, considerably more than the additional sal-ammoniac used. In the writer's practice, therefore, he finds it best to have a certain quantity of sal-ammoniac on the bottom of each cell, and to allow the liquid to maintain saturation by taking it up as it is wanted. There is also another kind of local action, due to impurities in the generating plate itself. Commercial zinc, especially cast zinc, often contains impurities, and it is not unfrequently in a different physical state in different parts. Either of these conditions, the presence of foreign matter or a different physical state, is sufficient to set up a local battery within the generating plate, causing waste of metal and adding resistance to the circuit.

(To be continued.)

VESEY'S ELECTRIC LARYNGOSCOPE.

The advantages of electric illumination for the surgical examination of interstices of the human frame have long been so fully appreciated that even in the days before the incandescent light was available minute Geissler tubes were successfully employed for this purpose. The instrument which is, however, in most general use in this country at the present time was designed by Mr. Arthur H. Vesey, A.M.I.C.E., and although primarily intended for the examination of the throat it is also employed in most of the London hospitals, and by many of the leading surgeons and physicians, for the various purposes above hinted at. The form of this instrument, which is illustrated in the accompanying figure, simple as it may appear, is in reality the outcome of nearly two years' study and experiment, in which Mr. Vesey received every facility and assistance from Dr. Felix Lemon, and from Messrs. F. Weiss and Son, the surgical instrument makers. Such an instrument has to fulfil many stringent requirements ; amongst others it must be capable of being dipped, without injury, into a disinfecting fluid, and must not become unduly heated in operation.

In the figure A is a mirror, which can be readily detached from the stem, and which stands at such an angle as to be capable of reflecting the image of the larynx. B is the incandescent lamp, which is fixed to the stem by a bayonet point, C, in which is an ingenious arrangement, ensuring a perfect contact without trouble. The lamp itself, which is of about half a candle-power, measures

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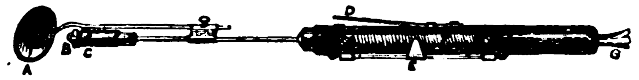
only ⅛in. in diameter, and, except at the extreme top, it is entirely embedded in plaster of Paris. The stem is hollow, and the conducting wires pass through it to the other end of the holder G, where they may be attached by means of a flexible conductor to the battery, which the operator usually carries in his pocket. D is a switch by which the circuit is closed at will, and E is a shifting contact sliding over a spiral of fine German silver wire in order to regulate the intensity of the current. These parts of the instrument are so designed that they can readily be manœuvred by the operator without shifting his grasp. We have given a detailed account of this instrument because it is not infrequent to find electrical appliances intended for surgical use which have been designed by electricians without very much surgical knowledge, or perhaps by surgeons of whom the converse holds good, with the result that some imperfection of detail hinders the success which



might otherwise have been attained. There is undoubtedly a legitimate and extensive field for the application of electricity in this direction, and it is equally certain that only by a combination of forces such as that of which the instrument we have described is the outcome can a full measure of success be attained.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

ADDRESS OF THE PRESIDENT, SIR CHARLES BRIGHT.

(Concluded from page 222.)

The French concession stipulated that "unless the experiment shall result in a favourable execution by the 1st September, 1850, the right conceded shall revert to the French Government." This object was attained, but nothing more. A copy of the messages transmitted was attested by some ten persons, including an engineer of the French Government, who was present to watch the proceedings; this was forwarded to Paris, and a prolongation of the privilege was granted. A more substantial cable was manufactured next year; the conducting wires consisted of four No. 16 gauge copper wires, surrounding a heart of tarred hemp, and covered with a bedding of the same material. The conductors were double-covered with gutta percha to the diameter of a quarter of an inch, the core being made at the Gutta Percha Company's Works, then under the management of Mr. Samuel Statham, a gentleman of great energy and business capacity. The outer covering was made of galvanised iron wire, laid on the core like an iron-wire pit rope. I am unable to say by whom this mode of sheathing was originally suggested, but Mr. Crampton, the engineer of the company (with whom was associated Mr. Wollaston), gave the order* for its application to Messrs. Wilkins and Weatherly, of High-street, Wapping. They were, however, stopped by an injunction of the Court of Chancery, for infringing the patents of Mr. R. S. Newall, of 1840 and 1843,† and the manufacture was carried on by his firm. The cable 24 miles in length and 180 tons in weight, was delivered on board the "Blazer," a hulk provided by our Government. Some delay arose from the litigation, and the manufacture was not finished until the 17th September. Mr. Crampton, who had contributed a considerable part of the capital for the undertaking, now took the laying in hand. During two stoppages, one from cessation of signals from the shore, the other from the parting of a tow-rope, a good deal of cable was wasted, and the length of cable finally proved too short by a mile. This, however, was made soon after, and spliced on to the laid part of the cable. This cable is still in working order, although many new lengths have been inserted from time to time to make good defects caused by damage from ships' anchors and deterioration. Its type, so far as the sheathing is concerned, continues to be the model for all submarine cables laid in comparatively shallow water. A piece of the cable, as actually laid, was exhibited by Mr. Brett at the Exhibition of 1851, in Class X.; also a vertebrated iron tubular cable, and another constructed with the addition of a chain of links for the purpose of giving greater strength in dangerous situations. Drawings of these are given in the report, and a council medal was awarded for them. The Submarine Telegraph Company (formed by Mr. Brett, Sir James Carmichael, Lord de Manley, and others) soon contracted with Messrs. Newall to lay a cable to Ostend. This company was the first in this country to value and to adopt the marvellous printing instrument of Prof. Hughes (our late President), so well known by his other inventions, as, for example, the microphone. His printing telegraph has been greatly employed by many foreign Governments, and afterwards again by our United Kingdom Telegraph Company here, and, as we all know, he was the Royal Medallist of the Royal Society last year. The instrument of which I speak is unequalled as a wonderful example of the greatest mechanical skill in its synchronism, and all its working parts, and also of ingenious electrical application thereto. Other cables were then laid by the Magnetic Company to Ireland—between Portpatrick and Donaghadee—and the Electric Company to Holland, with others, into the details of which time does not allow me to enter.* These cables were, with differences in the number of wires and dimensions, all, with one exception—that between Varna and Balaclava—made in the same style as regards the outer sheathing, namely, with outer iron wires, the wire not being *twisted*, but laid on spirally, with what is termed a sun and planet motion, in which each bobbin of wire makes one turn in the opposite direction for every revolution of the machine. At the end of the year 1855, the North American lines were laid as far as Newfoundland, and in Europe the Magnetic Company's lines were completed as far as the west coast of Ireland.

The practicability of uniting the great telegraphic systems, by means of a submarine cable between the shores of the Old and New Worlds, had for a long time engaged the thoughts of some of the most enterprising men of science and of experience in telegraphs. It was yet to be seen whether a cable could be laid in such great depths of water, and continuously for so great a distance, without mishap. But there was also another problem unsettled: Could so long a circuit be worked electrically? When wires are fixed to insulators upon poles in the usual familiar manner, there is no difficulty in telegraphing through the longest circuits which can conveniently be used; but when the wires are coated with gutta percha, inductive action comes into play, and a considerable retardation of the signal takes place, arising from the wires acting in the same manner as a Leyden jar.†

Having a great length of underground gutta percha covered wire under my control as engineer of the Magnetic Company, I carried out a long series of experiments by having the wires connected up backwards and forwards between London and Manchester, so as to form a continuous circuit of a length equal to that of a telegraph cable between Ireland and Newfoundland, or more than 2,000 miles. My method was to use a succession of opposite currents, which I had previously found to be successful with the magneto-electric instruments used by that company. I could only try my experiments at night, or on Sundays, when the traffic on the line was small. Mr. Whitehouse, a gentleman of very high intellectual power, and a most ingenious and painstaking experimenter, had been working in the same direction for some time upon the wires of some Mediterranean cables connected backwards and forwards, so as to get a length of about 900 miles.‡ The use of these wires had been allowed him by Mr. Brett, who was founder of the Mediterranean Electric Telegraph Company, and on my talking of my experiments with the latter one day at Greenwich, in 1855, he brought Mr. Whitehouse and myself together, the result being that we continued our researches thereafter conjointly until the beginning of the Atlantic line, when we had to divide our labours; he becoming the electrician, and I the engineer of the company.

In July, 1856, Mr. Cyrus Field, the deputy-chairman of the New York and Newfoundland Telegraph Company, left America for London empowered by his associates to deal with the exclusive concession possessed by that company for the coast of Newfoundland, and other rights in Nova Scotia. He had, for some time, been concerned with Mr. Brett in the project. He had been here before about telegraph business, and I had discussed the Atlantic line with him in the previous year. On the 29th of September, 1856, an agreement was entered into between Mr. Brett, Mr. Cyrus Field, Mr. Whitehouse, and myself, by which we mutually engaged to exert ourselves "*with the view and for the purpose of forming a company for establishing and working electric telegraphic communication between Newfoundland and Ireland, such company to be called the 'Atlantic Telegraph Company,' or by such other name as the parties hereto shall jointly agree upon.*" Mr. Field was—I am happy to say *is*—a man of extraordinary energy and power; rapid in thinking and acting, and endowed with courage and perseverance under difficulties, qualities which are rarely met with. Professor Morse, the electrician of the Newfoundland Company, had also arrived in London, and Mr. Whitehouse and I showed him one night, the 9th October, 1856, at the office of the Magnetic Company in Old Broad-street, that signals could be sent at the rate of 210, 241, and, in one experiment, at the rate of 270 signals per minute, through the continuous circuit of 2,000 miles of the company's underground wires between London and Manchester. The wires were joined backwards and forwards at Manchester and London, in each loop at both ends a galvanometer being inserted in the circuit to prove that the currents really passed through. By this the resistance, though not the *retardation* of the line, was largely increased. On the 20th October, 1856, the Atlantic Telegraph Company was registered, Mr. Brett heading the subscription list with £25,000, Mr. Field following him for the same amount. We then held meetings in Liverpool, Manchester, and Glasgow, which were addressed by all of us, the founders, and nearly the whole of the capital, consisting of 350 shares of £1,000 each, was subscribed for in a few days, principally by shareholders in the Magnetic Company.

I have no time to give a detailed account of the Atlantic telegraph; it would alone occupy an entire evening, and there are several books in which it is described.§ I cannot, however, leave this hiatus without tell-

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* See letter in *The Times*, Nov. 12, 1852, from Messrs. R. S. Newall and Co., of Gateshead-on-Tyne.

† Nos. 8,594 of 1840, and 9,656 of 1843.

* Particulars, with drawings and sections of the earlier cables, are given in "The Electric Telegraph," by Dr. Lardner. New edition, revised and rewritten by Edward B. Bright, F.R.A.S. (James Walton, 187, Gower-street. 1867.)

† There are several papers on this subject in the *Reports* of the British Association in 1854: "Experimental Observations on an Electric Cable," by Wildman Whitehouse; "On Magneto-Electricity and Underground Wires," by Edward B. Bright; "On Improvements in Submarine and Subterraneous Telegraph Communication," by C. F. Varley.

‡ See *Illustrated London News*, October 6th, 1855, for drawing and description of Mr. Whitehouse's apparatus. Also *Engineer*, January 30th, 1857.

§ *e.g.*—"The Atlantic Telegraph," by W. H. Russell, LL.D., Illustrated by Robert Dudley. (Day and Sons.) "The Electric Telegraph," by E. B. Bright. (James Walton, Gower-street). 1867.

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ing you what pleasurable recollections I have of those who assisted me so ably in my duties (as engineer-in-chief) in the last voyage—Mr. (now Sir Samuel) Canning, who had laid several cables; Mr. Henry Woodhouse, also an old cable layer; Mr. Everett, of the U.S.N.; and Mr. Clifford, now engineer to the Telegraph Construction Company. Irrespective of our business relations, we were all colleagues and friends together, and I never had a happier time on board ship. Mr. Whitehouse was equally fortunate in regard to Mr. J. C. Laws, Mr. Saunders, Mr. de Sauty, Mr. Collett, and other members of his staff, whose names I cannot now call to mind. I finally landed the first Atlantic cable at Valentia on the 5th August, 1858, and it is worthy of remark that just 111 years previously, on the 5th August, 1747, Dr. Watson astonished the scientific world by practically proving that the electric current could be transmitted through a wire hardly two miles and a half long; nevertheless, he showed at the same time that the earth could be used for the return circuit. The first messages which passed through the cable were one from the Queen to the President of the United States, and his reply. Many others followed of some importance; but this cable broke down on the 3rd September. Various causes have been suggested for this. Too high electric power being used, an unusually violent lightning storm at Newfoundland, and a supposed factory fault masked by the tar in the hemp, &c. I cannot give any opinion (as the cable was reported by the electricians in excellent condition after being completed by me, when it passed out of my charge), except that I agree with Mr. Brett that the manufacture had been pressed forward with too much haste*; which view was shared in by Mr. Canning† and Mr. Woodhouse.‡ Mr. Whitehouse had wished to test every separate coating of gutta percha during manufacture, but there was not sufficient time allowed for that to be done. The next great submarine telegraph cable was laid from Suez, in several sections between Suez and Kurrachee, at the end of 1859 and in 1860. 3,499 miles were made and laid by Messrs. Newall and Co. for the Red Sea and India Telegraph Company, under a guarantee from Government. It was a most disappointing failure, the sections breaking down one after the other; indeed, they do not appear to have been all at work at any time for the thirty days of continuous through working stipulated in the contract.§

In May, 1859, the Government, through Sir Stafford Northcote, then President of the Board of Trade, asked the advice of Mr. Robert Stephenson and myself respecting the form of cable to be used for a submarine line, which it was proposed to lay from Falmouth to Gibraltar, 1,100 nautical miles in length, and from 100 to 2,500 fathoms in depth. In my report I recommended a much larger copper conductor than ever used before, to weigh 3½cwt. per nautical mile, or 392lb., and the same weight of gutta percha as the insulator. This was precisely the same core which I had recommended the Atlantic Company to adopt in 1856, but it had all been settled by contract before I became their engineer. The relative figures in the Atlantic cable were 107lb. of copper, and 261lb. of gutta percha; those of the Red Sea 180lb. of copper and 212 of gutta percha per knot.‖ For the outer covering of the proposed Gibraltar cable, I advised different forms for the various depths—of great strength and low specific gravity for the deepest water, and of greater specific gravity for the smaller depths. This part of the report is not, however, of any importance, as the Government changed their plans, and in March, 1860, decided on laying a cable between Rangoon and Singapore, and the lighter cable, which was intended for laying in the deep water in the Bay of Biscay, and which would have been quite unsuitable for the Malay coast, was abandoned. Again, in January, 1861, in consequence of the war with China having come to an end, it was settled that it should be laid from Malta to Alexandria, and divided into sections at Benghazi and Tripoli. It was accordingly laid in the summer of 1861, with great success, by Messrs. Glass and Elliot, to whom the contract for laying was given by the Government. Mr. H. C. Forde was the engineer, and Mr. (afterwards Sir) C. W. Siemens the electrician for the Government. Full details of the construction, laying, and testing of this cable were given in two papers read at the Institution of Civil Engineers.¶ The work throughout appears to have been carried out with great care and due regard to the conditions taught by experience to be necessary in submarine telegraphy. The report and evidence of the Submarine Telegraph Committee was published during the construction of this cable. I consider it to be the most valuable collection of facts, warnings, and evidence which has ever been compiled concerning submarine cables, and that no telegraph engineer or electrician should be without it if beyond reach of access to it. It is like the boards on ice marked "Dangerous" as a caution to skaters.

The next great submarine cable enterprise was the Persian Gulf line, uniting the Turkish land telegraphs at the head of the Gulf, and the Persian land telegraphs at Bushire with Kurrachee; the failure of the Red Sea line, and the loss £800,000 over it, having led the Government of India to adopt the alternative telegraphic route by way of the Tigris Valley. A careful line of soundings was completed by Lieut. Stiffe (of what was then called the Bombay Marine) in 1862; and the bottom being favourable for a cable, the Government of India resolved to lay one, of great strength and durability, designed by Messrs. Bright and Clark, and appointed us, in the autumn of 1862, engineers to the work. The late Colonel Patrick Stewart, R E., was the very able Government Director of the entire line. The total length of cable was 1,450 miles, weighing no less than 5,028 tons, being by far the heaviest length previously despatched on one submarine expedition. The copper conducting wire weighed 225lb. to the knot, and the conductivity of the copper was raised to a higher point than had been attained before, amounting to nearly 90 per cent. of pure copper. In many of the older submarine cables laid before this point had received attention, the conductivity was as low as 40 per cent., and even lower. The copper wire was made of a segmental form, surrounded by a tube, all being drawn down from a large built-up copper rod of the same construction; so that while the wire was smooth and no interstice could be seen, it was the same mechanically as a strand, but superior electrically. The weight of gutta percha was 275lb. per knot. The Government of India contracted with the Gutta Percha Company for the core. The laying on of the outer sheathing was put up by tender upon our specification, and the contract was obtained by Mr. Henley, of North Woolwich. In putting on the outer sheathing, a wet serving of hemp was first applied with the view of discovering any defect in the insulator at once; the outer covering of 12 No. 6 B.W.G. galvanised iron wires was then applied, and over it a protective coating, respecting which I must say a few words, as it was afterwards applied to so many and such great lengths of telegraph cable. A patent was taken out in 1858 (No. 1,965) by Messrs. Clark, Braithwaite and Preece, for applying a covering of asphalte and hemp to the outer wires of a finished iron cable, with the object of retarding the decay of the zinc coating the iron wires of cables. Mr. Clark had acquired the interest of Mr. Preece (not our esteemed past-President), and, as Mr. Clark and I were in partnership at the time, I purchased Mr. Braithwaite's interest in it in 1860. It had been tried on a short length of cable laid to the Isle of Man from near Whitehaven, in 1859. The cable was passed through the hot asphalte contained in a revolving tank enclosing the bobbins of hemp. The mixture was made hot by charcoal fires outside. The insulation was damaged by this process, and the delay and injury were so great that it took more than a fortnight to get the 36 miles covered with it. Mr. Clark went away to the Red Sea in 1861. Nobody would use the patent after the Isle of Man cable experience, so I set to work to deal with the matter. The result of my study and experiments was that I devised and patented (No. 466, A.D. 1862) the system generally adopted in all cable works since, of applying the hot compound over the finished cable by an elevator driven from the machine, making the laying on of the hemp or jute and compound one operation, and saving the delay of the former double manufacture, and also that, as the supply of compound was arrested (if the closing machine was stopped for putting in a bobbin of fresh iron wire) no damage could be caused to the insulator. The cable was then passed through semi-circular rollers (a stream of water being poured over them), by which the coating was thoroughly pressed into all the interstices of the wires. Thus the coating was done at the same time by part of the cable machinery, and the danger of destroying the insulation, and the cost, delay, and damage of re-coiling were avoided. Moreover, after a great series of experiments, I arrived at an improved composition of mineral pitch, tar, and silica made from calcined flints ground to a powder, by which latter addition the boring tool of the teredo was damaged directly it touched it. This process has been highly successful, practically as well as pecuniarily, having yielded upwards of £30,000 to Mr. Clark and myself up to the time that my patent expired. I shall say no more about the Persian Gulf cable. I went out to lay it myself and everything went on without any hitch or mishap. All the details will be found (including a new mode at the time of joint testing) in a paper read by me at the Institution of Civil Engineers in 1865. The cable was, and has been, a complete success. By the date of the laying of the Persian Gulf cable, forming the first telegraphic connection between England, Europe, and India, the science of making and laying submarine lines was pretty definitely worked out, and no important improvement has been since introduced. I do not, therefore, propose to add further particulars relating to subsequent cables, the more so as they are to be found in many books, including our own *Journals* and technical papers. I should, however, observe that during my absence in India and Persia, in 1864, combinations were arranged leading to the formation of large cable companies, which materially and beneficially affected the future telegraphic communication across the sea. In March of that year, the India Rubber, Gutta Percha, and Works Telegraph Company was registered to take over the large works of Messrs. Silver, now generally called the "Silvertown Company," and in the following month the businesses of the Gutta Percha Company and Messrs. Glass, Elliot and Company were combined as the "Telegraph Construction and Maintenance Company." At the present time these companies and Messrs. Siemens have constructed very great lengths of cable, making the total 107,000 miles of submarine communication with all the important parts of the world, in which more than £37,000,000 capital is invested, according to calculations supplied me by Sir James Anderson.

I will advert to one further point before quitting the subject of submarine cables: The importance of thoroughly surveying and sounding the bottom along the route where a cable is proposed to be laid has been of late years more closely carried out than in early times, and I may remark that had this been always done, many of the failures of early cables after but a brief submergence would not have taken place. It is only by means of taking soundings, which should not be more than ten miles apart, that an even bed can be relied upon. Whilst laying the Lisbon-Madeira cable in 1874, the Telegraph Construction Company's ship "Seine," discovered

* "Evidence before Submarine Telegraph Committee," Q. 1,443.

† "Evidence before Submarine Telegraph Committee," Q. 1,493.

‡ "Evidence before Submarine Telegraph Committee," Q. 991.

§ The Submarine Cable Committee's Report furnishes all the evidence about this unlucky cable. Tight laying, overheating, excessive battery power, and fissures in the gutta percha, are all spoken of.

‖ "Appendix to Report of Submarine Telegraph Committee," p. 482.

¶ *Proceedings* of Institute of Civil Engineers, Vol. XXI. The first use of resistance coils for testing cables was with this cable. They had been used before for testing underground wires. See Specification of Patent, E. B. and C. T. Bright, No. 14,331, of 1852. The part referring to this mode of testing with known resistances is published in the "Submarine Telegraph Committee's Evidence," p. 53, with drawings; also, the "Museum of Science and Art," 1854, and "The Electric Telegraph," by Lardner and Bright, p. 76, edit. 1867.

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a bank in latitude 33° 47′ N. and longitude 14° 1′ W., the depth being about 100 fathoms, with 2,400 fathoms in its immediate neighbourhood. In 1879, Messrs. Siemens' telegraph ship, "Faraday," discovered shallow water in mid-Atlantic when laying the Atlantic cable of that year. These soundings, being of extreme practical importance for the welfare of submarine cables, are also of advantage to the scientific world generally, in increasing the knowledge of the depths of the sea and the nature of its bed. The Silvertown Company has given particular attention to this subject, as described in a paper "On Oceanic Shoals Discovered in the Steamship 'Dacia,'" read before the Royal Society of Edinburgh, in 1885, by Mr. J. Y. Buchanan, F.R.S.E. Before starting to lay the cable, the telegraph steamers "Dacia" and "International," in 1883, sounded from Cadiz towards the Canaries on two separate zig-zag routes; and over 100 soundings were taken in this way by each ship at distances of ten miles apart. In the course of these soundings the "Dacia" discovered a bank in latitude 31° 9′ 30″ N. and longitude 13° 34′ 30″ W., and depth 58 fathoms, in the vicinity of a 2,000 fathom depth; or about the height of St. Paul's Cathedral from the bottom to the surface as compared with some of the highest Swiss mountains. These soundings were in what otherwise might have been taken as the line of the Canaries cable. In 1885, and last year, the telegraph steamer "Buccaneer," belonging to the same company, made close surveys and soundings down the West Coast of Africa to a point as far south as St. Paul de Loanda, with a view to laying cables there; and the results were given by Mr. Buchanan in a paper read at the Royal Geographical Society in November last. There were over 1,000 soundings taken, besides noting the strength of the current along the coast, which is considerable.

I regret that time does not now allow me to do more than refer briefly to the means of doubling the transmitting power of cables by the highly ingenious duplex system invented by the Messrs. Muirhead, which is now applied most successfully to about 50,000 miles of submarine lines. Duplex telegraphy as applied to cables has been brought to a high degree of perfection, judging from the results that have been obtained on the Mackay-Bennett cables recently laid across the Atlantic. The system is simply a "bridge" method, in which two sets of condensers are kept balanced in connection with the cable and the artificial cable, without the insertion of wire resistance to any great extent. Dr. Muirhead informs me that on the New York and Canso cable of 826 knots the ordinary working rate was 21 words per minute, but when the duplex system was applied the rate of transmission was actually doubled, being 42 words per minute. Also, that on the long Atlantic cable of the same system between Canso, Nova Scotia, and Waterville, Ireland, of 2,353 knots, while the ordinary telegraph instruments gave a speed of nearly 16 words per minute, the duplex apparatus has yielded 30½ words—equal to an increase of 93¾ per cent. Referring again to the English telegraph companies and to their acquisition by the State, opinions have often been expressed that the Governments of the time made an improvident bargain, but I think I shall be able to show that such was not really the case. While the telegraph lines of the various countries in Europe, Asia, India, and in our Australian colonies were erected and worked by their respective Governments, in England not only the first telegraphs were started by private enterprise, but so carried on for 33 years (1837 to 1870) until purchased by Government. During this long period those engaged in the undertaking had provided the capital, incurred all the risk, and developed the telegraph system into a highly lucrative business, from which the profits, notwithstanding competition, were steadily increasing, so much so, that the nett earnings of the two largest companies (the Electric and Magnetic) ranged from 14 to 18 per cent. per annum. The companies were not desirous of parting with the systems they had created, but the transfer to Government was very strongly advocated by the press and others. Without, however, giving the companies particulars beforehand, a Government Bill was brought forward suddenly, as shown by the following extract from a pamphlet published at the time by Effingham Wilson, entitled "Government and the Telegraphs":—"On Wednesday, the 1st April, 1868, the new Chancellor of the Exchequer, Mr. Ward-Hunt, appeared at the table of the House of Commons to move for leave to introduce one of those anomalous measures known in parliamentary phraseology as 'hybrid' Bills (*i.e.*, public Bills affecting private rights), to enable Her Majesty's Postmaster-General to acquire, work, and maintain Electric Telegraphs. . . . Mr. Ward-Hunt rose to ask leave to introduce this Bill at 25 minutes before 6 o'clock. The House of Commons adjourns its Wednesday discussions at a quarter before six o'clock. The Chancellor of the Exchequer had, therefore, only ten minutes to develop 'the objects' of the Bill. Having fully exhausted those ten minutes, the Speaker intimated that the hour for terminating the discussion had arrived. Mr. Milner Gibson and Sir Charles Bright rose to address the House, but they were too late even to ask a question or obtain an answer, much less to raise any discussion on the principle of the measure." The Bill as at first framed was very arbitrary, and practically looked like confiscation; but, in view of the strong opposition of the companies, the Post Office authorities came to terms by agreeing to twenty years' purchase of the nett profits—that is to say, that Government acquired property yielding them 5 per cent. on the amount they paid, which they were able to raise at about 3 per cent. A parliamentary committee, consisting of the Chancellor of the Exchequer, Mr. Goschen, and others, then sat nine days, and thoroughly thrashed out the conditions of the Bill in July, 1868, while a Conservative Government was in power, and the terms arrived at were confirmed next year by the Money Bill brought in by a Liberal Government. Before the completion of the purchase at the beginning of 1870 the accounts of the companies were thoroughly investigated by accountants of the Post Office, and the existing plant was examined by their experts. The total paid to the telegraph companies was £5,847,347, of which the Electric and Magnetic had £4,182,362, the balance being divided between the following smaller companies:—United Kingdom, Reuter's, and London and Provincial. Most of the railways had telegraphs of their own, and derived revenue from messages, and also in some cases from payments made to them by the telegraph companies for way-leaves and other privileges. The value of these to Government was subsequently fixed by arbitration at £1,817,181. Upon national considerations the Government quickly extended the wires to a vast number of small places, which, though a great boon to the community at large, entailed a very large extra cost, especially as the capital outlaid in such extensions has been debited in the accounts as part of the charges against the revenue of each year. The reduction of the message rates to one shilling also entailed loss at first. These facts account for the Postal Telegraph Department not having profits to show such as made by the companies. Bearing upon this, I may mention that the companies handed over, in 1870, 48,378 miles of land wire and 1,622 miles of cable wires (irrespective of the railway wires worked by them), connecting together 2,488 telegraph stations; while at the present time the Post Office have no less than 153,153 miles of wire (including submarine wires used for commercial purposes), in communication with 5,097 offices. Thus the mileage has been trebled and the stations doubled. There are also 17,042 miles of wire used for private purposes. In addition to this the railway companies have about 70,000 miles of wire, making a gross total of 240,195 miles, and the weight of the iron wires employed is no less than 50,150 tons.

The following comparison of tariffs and messages for the past 30 years is interesting:—

Year.	No. of Messages.	Tariff and Remarks.
1885 ...	882,360 ...	1s. 6d. to 4s. Address free.
1860 ...	1,863,839 ...	Do. Do.
1865 ...	4,650,231 ...	1s. to 2s., and a 6d. rate in certain large towns.
1869 ...	*7,500,000 ...	*Estimated for year preceding transfer.
1870 ...	9,850,177 ...	1s. tariff for 20 words. Address free. †October to October.
1875 ...	19,253,120 ...	
1880 ...	26,547,137 ...	
1884-5...	†33,493,224 ...	
1885-6...	47,508,509 ...	6d. tariff for 12 words. Address counted. Also October to October.

I should, however, remark that on separating the inland messages in the last two returns from the foreign, press, &c., messages, the great immediate increase by the change of tariff becomes more evident, as these figures give 24,615,395 messages in 1884-85 sent at the shilling, and 37,692,249 in 1885-6 at the sixpenny rate; and for the last six months under review the inland sixpenny messages were at the rate of more than 42 millions per annum. The receipts have also turned the corner, showing an increase of £5,526 over the corresponding period of the shilling rate in 1885. This is partly accounted for by more *extra* words being now used by senders, the average amount paid per message being now 8¼d., while under the shilling rate it was 1s. 0½d.

I am indebted for these later statistics to the Postal Telegraph authorities, Mr. Patey, C.B., Mr. Graves, and Mr. Preece, F.R.S., all members of our council. If time had permitted I intended to describe Prof. Sir William Thomson's beautiful apparatus for working through long cables, and also his system of taking deep sea soundings by the use of a small steel wire, which is generally adopted. Nor have I been able to refer to telephones, which may be regarded as a branch of the telegraphs.

In conclusion, I beg to thank you for the consideration and patient attention you have accorded to my long address.

COMPANIES' MEETINGS.

The Eastern Telegraph Company (Limited).

The twenty-ninth half-yearly ordinary general meeting of this Company was held yesterday (Jan. 20) at Winchester House, Old Broad-street, E.C., under the presidency of Mr. John Pender.

The SECRETARY (Mr. George Draper) read the notice convening the meeting, and the minutes of the last meeting, which were confirmed by the present meeting, and signed as correct by the Chairman.

The CHAIRMAN stated that the revenue for the half-year ended the 30th September last had been £292,229, or £39,190 less than in the corresponding period of the previous year. This reduction was divided as follows:—Indian and trans-Indian traffic £9,000, Egyptian £23,000, and Portuguese, Spanish, Turkish, &c., £9,140. They had had ½ per cent. extra dividend (representing £1,950) on their shares in the Eastern and South African Company. As to the Indian business £4,000 of the decrease might be attributed to the reduction of the tariff from 4s. 7d. to 4s. per word, which came into operation on the 1st July. The falling off in their Egyptian traffic was caused by the general quieting down of that country. There being no news of importance, the London papers had almost ceased to send special messages, and Government messages were not so frequent as in the previous year. At the same time, however, there was a slight increase in their commercial business with Egypt. Of the falling off in their other traffic, £7,000 out of the £9,000 might be put down to the very large reductions which they were forced to make at the Berlin Conference of 1885, the reduced tariff having come into force on the 1st July. He was, however, pleased to say that the traffic generally was increasing. The total working expenses had amounted to £81,025, or £5,910 less than in the corresponding period of the previous year. The general expenses in London had been £7,964, or £59 less. The working expenses at stations had been £58,129, against £60,497. The expenses attending

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repairs and renewals of cables had been £53,965, or £8,677 more. The repairs in the half year had been exceptionally heavy, especially on the Direct Lisbon line, where the "Electra" had laid in 191 miles of new cable. That, with the portions previously renewed, completed the renewal of three-fourths of this line. Other important repairs had also been effected by their ships, particularly the repair by the "Mirror" of the Zante-Canea cable. That cable had been broken by an earthquake, necessitating an expenditure of fourteen miles of new cable. After charging all expenses, including income-tax, providing for interest on debentures, debenture stock, and preference shares, they were able to maintain their dividend of 5 per cent. per annum. They would carry forward to next account £13,091, against £32,649 in the corresponding period of last year, and, judging from their present traffic, they might at least hope to carry a fair amount to reserve at the end of the financial year. He had received several letters in which the writers, the majority of whom were ladies, had expressed their disappointment at not receiving a bonus, but the shareholders were aware that when they first agreed to deal with the question of a bonus they decided that it should be kept apart from the dividend, and that they should try and maintain a 5 per cent. dividend, which would be a reliable distribution, while the bonus might be a fluctuating item. The reductions which they had been obliged to make by the Berlin Conference had reduced their income by £50,000 a year, which amount was just the loss of the bonus. As he had stated on many occasions, any immediate reduction was a present loss to the Company, and it required time to be recouped. He had no doubt they would recoup it in a short space of time. Since last September they had found a very considerable improvement in traffic, but until they met six months hence he was not prepared to say whether they would have a bonus or not. If, however, they went on as successfully as they had done in the last month or two they would have done two things—reduced the tariff, so benefiting the telegraphing public, without reducing their returns to the shareholders. Their traffics were increasing, and, as he had said before, the telegraph system was the best barometer of trade which they possibly could have. He, therefore, thought the improvement in trade must be pretty general. The loss on their Egyptian traffic in the half year had been about £23,000, the whole of which they might not be able to recoup, because a good deal of it had sprung out of exceptional circumstances; but if trade improved, as they expected it would, he thought they might recoup that amount to a very considerable extent. The expenses of repairs had been very heavy, which was a matter practically beyond the control of the Directors. It was, however, very satisfactory to know that they could repair them. In the position which the Company occupied, they must look ahead, and be prepared, should war break out, to be entirely independent of all their land system existing through France. They must look forward at no distant date to make themselves thoroughly independent on their system between Land's End, Gibraltar, and Malta. That was a matter they now had in view. They had another string to their bow, should anything occur, in the controlling interest which they had acquired in the Direct Spanish cable. Through the energy and perseverance of their managing director, Sir James Anderson, the large interest which the Eastern Company had in the Direct Spanish Company had been made a living thing. They would now get a dividend on that investment, and should war break out the chances were that they would be able to connect with that system the Company's system in the Mediterranean, and thereby obtain an alternate line in the event of their line through France being inoperative. All their cables were now in good working order; and they were about to lay a short cable from Gibraltar to Tangiers. That was taking possession of another important link in a chain of telegraphs, which was likely to be materially extended along the West Coast of America. Within a few weeks there was to be a Conference in London of representatives of our colonial possessions. At the conference the question of cheap telegraphy would be discussed. The Eastern Extension Company and themselves had got a scheme, and he believed it was a sound and the only practicable scheme for reducing the price of telegraphy to those very distant places. This scheme would be submitted, and they hoped it would reduce the rates by something like one-fourth of the present rates, leaving in the hands of the Government the power to regulate those rates and secure for the shareholders a permanent and guaranteed dividend. If they could carry out that scheme they would have placed submarine telegraphy in the place which it ought to occupy, being as it was one of the greatest and most important contributions which science had given to civilization during the long reign of the Queen. He concluded by moving the adoption of the report and accounts.

The VICE CHAIRMAN (the Marquis of Tweeddale) seconded the resolution, which was at once carried unanimously without discussion.

On the motion of the CHAIRMAN, seconded by Sir JAMES ANDERSON, Mr. George Garden Nicol was re-elected to his seat at the Board, as was also Mr. John Denison Pender, on the motion of the CHAIRMAN, seconded by Lord SACKVILLE A. CECIL.

Mr. GIBB next proposed, and Mr. STARNES seconded, the re-election of the auditors, Mr. Henry Dever, and Messrs. Quilter, Ball, and Co. The resolution was unanimously approved.

A cordial vote of thanks was then passed to the Chairman and Directors, on the motion of Mr. HURST, seconded by Dr. WALTER, both of whom acknowledged, in eulogistic terms, the services which the Board had rendered in promoting the welfare of the Company.

The CHAIRMAN, in reply, assured the shareholders that while the present Directors remained in office the interests of the Company would be maintained in a way which would meet at their half-yearly meetings with the full recognition of the proprietors, as on the present occasion.

The proceedings then terminated.

A full report of this meeting will appear in our next issue.

BUSINESS NOTICES.—Messrs. King, Mendham and Co., electrical instrument makers, of Bristol, who are well known as having made a speciality of Wimshurst induction machines, have recently found it necessary to enlarge their works situated in Narrow Wine-street and Fairfax-street, and have secured additional premises in Denmark-street.—Messrs. J. E. and S. Spencer, tube manufacturers, inform us that in consequence of their recent premises having to come down they have removed their London office to 14, Great St. Thomas Apostle, Cannon-street, E.C.—We understand that Messrs. Alfred Slatter and Co. (Limited) are, in consequence of increased business, removing to larger premises, at 45, Tabernacle-street, Finsbury.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Jan. 19.		Business Done Week Ending Jan. 19. Highest.	Lowest.
Anglo-American	33,	34	34	33½
Do. Preferred	56,	57	57	56½
Do. Deferred	12,	13	12¾	—
Brazilian Submarine	10⅞,	11⅛	10⅞	10 13-16
Cuba	11½,	12	11½	—
Do. Preference	18,	19	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Preference	7,	8	—	— xd.
Direct United States Cable	8¼,	8½	8¾	8⅝ xd.
Eastern Telegraph	10¼,	10½	10½	10¼ xd.
Do. 6 per Cent. Preference	13,	14	14	13¾ xd.
Do. 5 per Cent. Debentures, 1899	107,	110	—	—
Eastern Extension	10¾,	11	11	10¾ xd.
German Union	8¾,	9¼	—	— xd.
Globe Telegraph and Trust	5,	5¼	5⅜	5 1-16
Do. Preference	12¼,	12½	12½	12¼
Great Northern	13⅛,	13⅜	13¼	13¼
Indo-European	34,	35	35	—
Reuter's	7,	7½	—	—
Submarine	190,	200	195	—
West India and Panama	¾,	1	¾	—
Do. 1st Preference	8½,	9	9	8¾
Western Brazilian	7⅝,	7⅞	7 13-16	7¾
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	¼,	⅜	—	—
United Telephone	12½,	13	12⅞	12⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¼,	2¾	—	—
Do. (fully paid)	3¾,	4¼	—	—
Swan	1⅝,	1⅞	1½	—
Maxim Weston	¼,	⅜	—	—

MISCELLANEOUS.

Telegraph Construction	39	40	39½	—
India Rubber, Gutta Percha, and Telegraph Works	24	25	24½	24⅜

THOMPSON, DOWSING & REW,

Electric Light Engineers, Contractors & Erectors.

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NOTES.

THE GREAT ST. BERNARD MONASTERY.—The well-known monastery in the pass of the Great St. Bernard has been connected by telephone with the town of St. Pierre.

EDISON'S ILLNESS.—The latest information states that Edison's condition is still such as to cause the gravest anxiety to his friends. He is suffering from an attack of pleurisy.

THE CONTINENTAL EDISON COMPANY.—We are informed that the *Société Electrique Edison* has been amalgamated with the *Société Industrielle et Commercial Edison*, under the title of the *Compagnie Continentale Edison.*

THE EDISON ELECTRIC LIGHT COMPANY.—"The Edison Company for Isolated Lighting" has now been consolidated with "The Edison Electric Light Company," the latter name being retained as the title of the new company.

WOODWORKING MACHINERY.—Messrs. George Richards and Son, of Altrincham, send us a copy of their catalogue of woodworking machinery. These labour-saving appliances are probably well worth the attention of electrical instrument makers.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended January 21 were £3,243, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

A SWEDISH LAMP.—It is stated that experiments in the manufacture of glow lamps have been going on during the last four years at Uto, a town near Stockholm, and have now resulted in success. A company, with a capital of 125,000fr., has been formed.

THE EASTERN TELEGRAPH COMPANY.—The above company notify that the coupons on their 5 per cent. debentures, due on 1st February next, will be paid on and after that date at the banking house of Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C.

GAS EXPLOSION IN AN ELECTRIC LIGHTING STATION.—At a town in Ohio, where natural gas was used as fuel for driving the engine in an electric lighting station, a serious explosion occurred on Christmas Day, wrecking the machinery and buildings, and killing the engineer.

ELECTRIC LIGHTHOUSES.—Dr. Hopkinson's account of the electric lighthouses of Macquarie and of Pino, which was read before the Institution of Civil Engineers last month, has just been issued in pamphlet form, together with the verbal and written discussion to which it gave rise.

BRAZIL.—Advices from Rio de Janeiro by the last mail state that an electric light enterprise has been organised at San Paulo, for the purpose of lighting private residences and business establishments, under the title of Marques, Moutte and Co. The capital subscribed is 100,000 milreis.

COUNTRY HOUSE INSTALLATION.—We are informed that Mr. Henry Boddington, of Manchester, has decided to light his country residence, Pownall Hall, by electricity. The installation has been placed in the hands of Messrs. Dorman and Smith, of Manchester, and will consist of about 170 lights.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The company give notice that the coupons on their 5 per cent. debentures, due 31st inst., will be paid on and after that date at the Alliance Bank (Limited). Coupons must be left three clear days for examination. The traffic receipts of this company for the week ended January 21st amounted to £3,963.

ISLE OF MAN STEAMERS.—The new Isle of Man Steam Navigation Company are having their steamers fitted with the electric light. Messrs. Dorman and Smith, of Manchester, have received an order to proceed with the first steamer of the fleet, which will be placed on the station on the 1st May next.

THE GENOA TELEPHONE EXCHANGE.—One of the daily papers states that the damage inflicted upon the overhead wires at Genoa by a recent snowstorm has been so great as to make it necessary for the company to suspend its operations altogether. We have, however, some reason to doubt the accuracy of the statement.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY.—The directors of this company have issued dividend warrants for the balance of dividend for 1886 at 6 per cent. per annum., payable on the 1st February next. An interim dividend of 3 per cent. for the half-year ending 30th June was declared in July last.

A TELEPHONE BRIDGE.—Messrs. Siemens and Halske, of Berlin, have recently introduced a very compact and portable apparatus, consisting of a "metre" bridge in which the wire is bent into a circle, and in which the usual galvanometer is replaced by a telephone. A similar arrangement would be certain to have a sale in this country.

PENZANCE.—At a public meeting, recently convened by the Mayor of Penzance, to consider the question of lighting the streets of the town by electricity, a somewhat lively scene occurred owing to the opposition organised by the gas interests. Eventually resolutions in favour of the scheme were declared carried by very large majorities.

INCANDESCENT LAMP RUMOURS.—The *Electrical World* of New York says:—"There is a well-defined report current that one of the most distinguished American inventors, devoting his attention chiefly to the subject [of incandescent lamps], has already succeeded in far surpassing his previous work in this direction; and we have reason to believe the report to be true."

PROF. A. G. BELL.—We regret to note that a serious fire recently broke out in the upper story of the house owned by Prof. Alexander Graham Bell in Washington, and caused a loss of $50,000. The origin of the fire is unknown, but it is supposed that it began in the laboratory. The library, containing about 5,000 volumes, principally of a scientific character, was almost totally destroyed.

PROJECTED CENTRAL LIGHTING STATIONS.—The following towns upon the Continent have recently decided to carry out central electric lighting:—Wiesbade and Lubeck, in Germany; Valencia, in Spain; Saint-Aignau-sur-Cher, in France; Filipstad, in Sweden; and Christiana, in Norway. The last-named town has received an offer from an American company, but the matter is still under consideration.

TENDERS FOR TELEGRAPH MATERIAL.—Tenders are invited by the South Indian Railway Company for the supply of telegraph material and apparatus. Specifications may be obtained at the offices of the company, 55, Gracechurch-street, E.C., and must be returned by the 8th Feb. (It may be as well to note that this is a separate tender from the one mentioned last week for the Great Indian Railway).

THE ANGLO-AMERICAN TELEGRAPH COMPANY.—At a meeting of the Board of Directors of this company, held on the 21st inst., it was resolved "That the balance of the revenue account for the quarter ending 31st December, amounting to £18,847. 3s. 2d., be placed to the credit of the renewal fund." The register of transfers will be closed from the 21st inst. to the 4th February, both days inclusive.

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TYNEMOUTH.—At a special meeting of the Tynemouth Town Council, for the purpose of taking into consideration the lighting of the new market with the electric light, and putting in an engine of sufficient power for the purpose of hereafter lighting the Town Hall Buildings and Free Library with the electric light, after some discussion it was decided to refer the matter to the Trade and Commerce Committee.

ELECTRICITY AT THE SAVOY.—In one of the scenes of Gilbert and Sullivan's new opera, "Ruddy-gore; or, the Witch's Curse," the stage being darkened, the movement of the conductor's *bâton* is rendered visible by means of a small incandescent lamp fixed on the top. This device was, we believe, employed for the first time a few months ago at Berlin, on an occasion when the massed bands of several regiments serenaded the Emperor at night.

SUN-SPOTS AND TERRESTRIAL MAGNETISM.—The connection between the variations of the elements of the earth's magnetism and the passage of spots, and faculæ across the disc of the sun has received further confirmation by observations extending over a period of six months, undertaken by M. Marchant at the Lyons Observatory. Readers interested in this subject will find a full account of the observations in the last number of the *Comptes Rendus.*

UNDERGROUND WIRES AT BIRMINGHAM.—The suggestion to utilise the kerb of a footpath for the purposes of a wire conduit, by constructing it in the form of a cast-iron box, is not by any means a new one. We are, however, pleased to see that the Corporation of Birmingham are going to give the system a trial. At present, however, though the Corporation may put down such a conduit, it by no means follows that the telephone companies will be induced to use them.

THE INDIAN TELEGRAPHS.—The report of the Indian Telegraph Department for the year 1886 states that the operations of the preceding twelve months have been of a very satisfactory and successful character. The lines have been increased by 2,123 miles, now making a total of 27,510 miles. The messages sent amounted to nearly 2½ millions, being an increase of 13 per cent. on last year. The message revenue increased by 4,63,025 rs., and the gross revenue by over 51 lacs.

THE MICROPHONE FOR DETECTING LEAKS.—At the recent Congress of Gas and Water Engineers held at Eisenach in Germany, it was stated that many German water companies had adopted the microphone as a part of the regular equipment of their turncocks in order to enable them to detect the presence and estimate the importance of any leakage. The microphone is fixed upon a plate which can readily be attached to a stopcock. It is said that the presence of a leakage at the rate of only a few drops a minute can readily be detected by this means.

THE FAWCETT MEMORIAL.—The memorial erected in the Baptistery of Westminster Abbey to the late Postmaster-General is to be unveiled by Lord Granville this afternoon. Previous to the unveiling a short meeting will be held at 4 o'clock in the Jerusalem Chamber, at which the Duke of Westminster, chairman of the memorial committee, will preside, and will submit the report and statement of accounts. The musical part of the ceremony following will be rendered by the Choir of the Royal Normal College and Academy of Music for the Blind.

ITALIAN CONTRACT OPEN.—We have received the following communication from M. G. Pedretti, of Milan:—"M. Pedretti seeks either a banking house or an electrical company which feels disposed to take up and work a central electrical installation in a town of 70,000 inhabitants in Italy. The legal agreements for placing one thousand incandescent lamps in a radius of five hundred yards could at once be given as a preliminary contract. No doubt in the near future a large increase of the lighting of the streets and public roads will take place. For any inquiry apply to M. G. Pedretti, Via Ancona 6, Milan."

BRADFORD BOARD OF GUARDIANS AND THE ELECTRIC LIGHT.—At the meeting of the Bradford Board of Guardians on Wednesday, a letter, signed by the town clerk, was read, its purport being that the Corporation are prepared to undertake to supply electric lighting if such be the wish of the ratepayers in any given district of the borough. They therefore wished to know whether the board would agree to be supplied with electric lighting for a fixed period of three years. Alderman Duggan said he thought the Guardians were quite satisfied with the present gas supply. He moved that the clerk be instructed to reply to the communication to the effect that the Guardians were not disposed to be supplied with electric lighting. Mr. Hitchen seconded the resolution, which was adopted.

THE NEW SEWERAGE SCHEME AT THE HOUSES OF PARLIAMENT.—ELECTRIC ARRANGEMENTS.—The new drainage system which has just been completed at the Houses of Parliament at a cost of £11,000, on the Shone Hydro-Pneumatic system, involves the use of gas engines for compressing the air by which the ejectors are worked. Ordinarily one 4 horse-power engine is amply sufficient for all requirements, but in the event of excessive rainfall additional power is required, and no less than four engines have been provided. The necessity for increasing the motive power is signalled to the engine room from the ejecting chamber, and the exact height of the sewage is shown by one of Mr. Julius Sax's Automatic Electrical Tidal Water Gauges. The height of the water is indicated by means of two index hands moving over a clock face.

"EXAMPLES OF EXERCISES."—We have received from Messrs. James Maclehose and Sons, of Glasgow, a copy of a a little book of 60 pages, whose complete title is "Examples of Exercises, given in the Natural Philosophy Class of Glasgow University, from 1865 to 1885, with indications how to answer them, by Magnus Maclean, M.A." The nature and scope of the work will be sufficiently clear from the title-page, and we need only add that the "indications" seem to us in most cases to be extremely well put, the hints being sufficiently definite to enable the student to see his way through a difficulty, without doing all the thinking for him. There are many men—electricians and others—whose student days are over, who would find themselves all the better able to deal with the work that comes before them if they refreshed their memories by running rapidly through such a book as this.

THE PULUJ INCANDESCENT LAMP.—At Steyr, in Austria, a very remarkable incandescent lamp, known under the name of the "Puluj," is manufactured. According to *Electricité*, the filament consists of a fibre of Manila hemp. The chief peculiarity in the treatment employed is that, according to our authority, the carbonisation is effected by the current itself. For this purpose the raw filament is placed in a bath of mineral oil, and connection being made with a dynamo of high E.M.F., the filament is rapidly carbonised, with the result that not only is a remarkably homogeneous structure obtained, but also one possessing considerable mechanical strength—24 kilogrammes per square millimetre is spoken of. We confess that the possibility of effecting the carbonisation of a filament by such a process as is here described appears to us highly remarkable. Still more remarkable is the statement that Puluj lamps, having a resistance of 214 ohms, will give a light equal to

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20 candles with a difference of potential of only 20 volts. Even if the 214 ohms represent the hot resistance this is equivalent to an efficiency of 2½ candles per watt!

THE UNION COMPANY.—In these days a new manufacture ing company is something of a *rara avis*. The Union Company, whose prospectus will be found in our advertising columns, is promoted for the working of a number of patents, principally connected with secondary batteries. We have always held that such batteries are of equal importance to the dynamo and the lamp in electric lighting, while there is also a large field for their services in other directions. Were there no question of patents raised with regard to this company's operations, we should speak far more freely as to the prospects opening out to electrical work in this particular direction. Mr. Moulton, it seems, has given his opinion as to the patents, and no greater authority exists; hence we should imagine the opinion is conclusive. Prof. Forbes, too, is exceedingly careful in his opinions, and the authorities being favourable to the battery and the validity of the patents, there need be no hesitation in saying that the demand for a thoroughly trustworthy and satisfactory secondary battery is likely to be quite large enough to keep half-a-dozen companies like this in occupation. The question for investors is simply—Is the battery good?

NATIONAL TELEPHONE COMPANY.—EXTENSION OF SYSTEM. On the 19th inst., this company opened exchanges in Galashiels and Selkirk, with junction wires between the two towns. The number of subscribers on the opening day was 25 in Galashiels and 11 in Selkirk. As the respective populations of the towns are only 16,000 and 6,000, the commencement may be regarded as very promising. At a banquet given at the Commercial Hotel, Galashiels, in honour of the event, Mr. A. R. Bennett, the company's general manager for Scotland, in proposing "Prosperity to the Border Towns," said that an exchange would be opened at Dunfermline before the end of January, after which there would be only two towns of 16,000 inhabitants in Scotland without a telephone exchange, these being Dumfries and Hawick. He sketched the company's progress in the erection of trunk lines, which has recently been very rapid, and mentioned many of the uses to which the telephone may be put. The toast was replied to by the Provost of Selkirk, after which "Success to the Company" was proposed by the Town Clerk of Galashiels. The guests were afterwards entertained by telephonic music originating in Selkirk.

"PRIVATE AND CONFIDENTIAL."—We confess that it was not without a feeling of surprise that we noticed last week in one of our electrical contemporaries the publication at full length of a *quasi*-official document which (at any rate in the copy which reached this office) bore the words "Private and Confidential" conspicuously printed on the front page. As we took occasion to remark last week, we certainly think that there is no sufficient reason why the authorities should not have seen fit to permit the publication of at least the greater portion of this document. But whatever may be one's private views upon such a matter, we had thought it usual, at least among technical journalists, to respect an intimation of this description. Since writing the above we have received from a correspondent a rather clever little farcical sketch which appears to have some bearing upon the matter alluded to. We should scarcely feel justified in inserting this production at length; but we may mention that the *dramatis personæ* are an editor and a printer's devil. After a somewhat humorous dialogue, in which the editor expresses his inability to supply the demands of the P. D., a document, marked "Private and Confidential," arrives by post, and is delivered into the clutches of the devil, the leading character remarking that this kind of matter is very "filling at the price."

A NEW FRENCH ELECTRICAL SOCIETY.—The International Society of Electricians not having adequately fulfilled the expectations which (in some quarters) were formed at the time of its foundation, a proposal has been set on foot in Paris for the formation of a new society to be called the "Société Electrotechnique de France." The objects of the society as set forth by the promoters are of a laudable character, namely, "to study the various applications of electricity, and to undertake the collection of documents bearing upon the history of the subject." The constitution of the new society, as at present proposed, will be of a somewhat peculiar character. There is to be no entrance fee, and the annual subscription is to amount to an equal sum. The number of members is to be strictly limited to 100, of which 50 may be residents in Paris, 20 in the provinces, 20 in countries outside France, and 10 will be honorary. Applications for admission to membership may be addressed to M. Maiche, president of the society. We shall be delighted to learn that the 10 original honorary members are all of English nationality, but there will, we trust, be no unseemly rush to obtain this honour.

SOME FIGURES.—Mr. Carl Hering, writing in the *Electrical World*, gives the following statistical statements, which possess some degree of interest:—"The energy set free on firing a small pistol is about 600 foot-pounds, the pressure being 40 tons to the square inch. The charge of a small Leyden jar was ·000008 coulombs at 50,000 volts, or about 0·288 foot-pounds of energy. A watch consumes about one fifty-four-millionth of a horse-power; so that the energy communicated to the bullet would serve it for two years, while that of the Leyden jar would be exhausted in about eight hours. This discharge of the Leyden jar is about double the energy consumed in a telegraph line of 100 miles. An Edison telephone-transmitter requires about one-thousandth of the energy in a watch; it could, therefore, be worked for 2,000 years on the energy exerted in the pistol. A lightning flash of 3,500,000 volts and 14,000,000 amperes and lasting one twenty-thousandth part of a second would run a 100 horse-power engine for ten hours." We do not hold ourselves responsible for the correctness of these figures, but the younger students of physical arithmetic will find it a useful exercise to undertake their verification.

THE UNITED TELEPHONE COMPANY AND ITS CLIENTS.—Mr. R. J. Fraser writes to the *Daily News* as follows:—With reference to the inquiry made by Mr. Arthur J. Humphreys as to what action the tenants of the United Telephone Company propose to take in view of the telephone communication having broken down since the 26th ult., I beg to state that on the 8th inst. I wrote to the telephone company that I should require them to return a part of the £20, the annual rent paid by me, proportionate to the time during which the communication remains interrupted. In the alternative I claimed that the year for which the rent had been paid should be extended for a like period. On the 10th January I received a reply from the secretary stating that the directors, "while not admitting any liability for loss of communication, had the matter under their careful consideration, and that each case would be treated on its own merits." I have referred to the printed contract of the company, and I observe that, in the first article, the company agrees to "erect and maintain in working order the apparatus." Under this contract I am of opinion that the tenants can claim a return of the proportion of the money paid by them. The more generous course would

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be to consent to the time of the contracts being extended, but this is a question for the consideration of individual tenants.

Birmingham Telegraph Clerks and the Civil Service Inquiry.—A largely-attended meeting has been held at the Acorn Hotel, Birmingham, to consider what action should be taken to lay the grievances of telegraphists before the Royal Commission of Inquiry into the Civil Service. The chairman commented upon the position in which they were placed in consequence of the Postmaster-General having declined to furnish the particulars necessary for a clear and reliable statement of their case. They would, however, take care to utilise their own resources of information to the fullest extent, and in presenting the results to the Commission they would point out the incompleteness of the evidence in consequence of essential facts being withheld by the department. It was their earnest desire that the state of agitation and unrest which had existed in the telegraph service more or less since its transfer to the State, and which was so detrimental to the public service, should be brought to an end by being effectually dealt with by the Royal Commission. They wished simply to lay before that body a true and plain statement of their grievances, and by the decision of an impartial tribunal they were willing to abide. A resolution was unanimously passed expressing satisfaction at the appointment of the Commission. Votes of thanks were accorded to Mr. Puleston and other members of Parliament for the interest they had manifested on behalf of the telegraph service, and to the Press for the advocacy of their cause.

The Telephone in Austria.—On this subject we have received the following notes from Herr Rudolph Krause, of Vienna :—" In spite of all the difficulties the telephone has to encounter in Austria, owing especially to the poverty of the inhabitants of most of the towns, the progress during the last year has been very fair, and is owing to the generous way in which the Telephone Company of Austria, working through the Consolidated Telephone Construction and Maintenance Company, has introduced low tariffs. In the towns worked by this company, viz., Prague, Trieste, Graz, Lemberg, Czernowitz, Bielitz, Reichenberg, and Pilsen, the average tariff is about £6 to £7 per annum; the number of subscribers has increased from about 1,200 at the beginning of last year to about 1,600 now. How great the difficulties are, and how carefully the company must work in order to make a profit, may be seen by the fact that the royalties in Austria are the highest in the world, as compared with the price of subscription, being nearly £1 on each subscriber. It is also well known that Austria is the most heavily taxed country in Europe. It is therefore gratifying to see that the company is now getting on at last, and it is to be hoped that the Government will continue to enlarge its concessions. All lines belonging to the company are built with silicium bronze wire 1·1 to 1·2 mm. diameter. They are supported by iron poles securely fastened to the roofs. Experience has taught the company that for overhead work there is no wire to compete with this, and that this wire bears best the brunt of the great snowstorms of that country. Damage is done, of course; but it is almost always small, and repaired in a few days with little cost. With so low a tariff underground wires are quite out of the question."

Firing Torpedoes by Electricity.—*The Times* gives the following description of the arrangements for firing torpedoes by electricity on board a torpedo boat built for the Admiralty by Messrs. Thorneycroft:—" Stated briefly, a torpedo tube is simply a gun for ejecting locomotive torpedoes, the ejecting medium hitherto being usually compressed air, but now, and in the case of the boats under notice, gunpowder. The *modus operandi* of loading one of these tubes and discharging the torpedo is as follows:—First, the torpedo, with its 'business end' duly filled with gun cotton and its air reservoir charged with compressed air, is placed in the tube, with the end of the horizontal rudder frame pressing against the retaining catch; then the small silken bag containing pebble powder is placed in a pocket inside the door of the tube and the door closed and secured. A second cartridge, brass cased, containing finer powder, and capable of being discharged by electricity, is then inserted in a piece of mechanism on the outside of the door, which serves the double purpose of retaining the brass cartridge while being fired, and of serving as an ejector subsequently. A heavy weight on the end of a lever at the side of the tube is then raised and retained in the raised position by means of a catch, which may be released by an electro-magnet, and a forked appliance, to which the wires from the battery are attached, is inserted in the firing cartridge. The tube is now ready for firing, and all that is necessary to discharge the torpedo is to press a button so as to make contact between the two wires. The first result of this operation is to release the catch holding the weight, which, falling, pulls back the retaining catch, then makes contact with the wires leading to the firing cartridge, and so explodes the powder. The torpedo is then blown out of the tube, the air valve in the torpedo being opened as it passes along the tube by means of a tripper in the top of the tube. The noise of the discharge is no louder than would be made by clapping the hands sharply together with the palms a little hollow. Each of the boats under notice is fitted with five of these tubes, one being fixed in the bow, and four revolving in pairs round each of the two conning towers."

"Electric Meteorology."—Under the title of "Electric Meteorology, a letter to the Right Hon. the Earl of Carnarvon," we have received from Mr. G. A. Rowell a pamphlet of which much of the contents are of a decidedly pathetic character. It appears that Mr. Rowell, whose name we confess was not previously known to us, has arrived at a very advanced period of life, and although, as he explains, he had not the advantage of much education during his earlier years, yet from a child he has taken the greatest possible interest in the problems of meteorology. Many years ago he suggested a theory of a somewhat comprehensive character, bearing upon the determinating causes of rain, storms, the aurora, and terrestrial magnetism. The theory met with an appreciative reception from the late Prof. Baden-Powell, who in the year 1840 read Mr. Rowell's paper on the subject before the British Association. The ideas suggested were sympathetically discussed in the scientific journals of that period, and during the whole of his life Prof. Baden-Powell appears to have taken opportunity from time to time of referring to the matter; and other scientific men also listened with interest to Mr. Rowell's suggestions. "On all these points," says the author, "I considered that I had fair grounds for hope of aid in the advance of the theory, or at least a fair consideration of its merits; but after the death of those I have named, and others who had adopted the theory and encouraged me to go on with it, all my efforts to advance the theory became useless, as, without investigation or disproof on any point, it seemed to be stamped out with contempt, and thus its progress has been effectually prevented both here and elsewhere." The author then refers to his advanced age, and the extreme disappointment which he has felt as the hope of seeing his ideas at least fairly discussed has gradually faded away. The pamphlet is throughout couched in dignified but modest terms, and the author does not seek pecuniary aid, nor has he had any. We regret that our space does not permit us to enter

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upon any discussion of the theory itself, which belongs to meteorological rather than electrical science, but we advise all who are interested in the subject to send for a copy of the pamphlet to Mr. Rowell, whose address is 2, Alfred-street, Oxford.

Electric Lighting at Messrs. Rhodes' Hadfield Mills. On Wednesday week a number of Manchester gentlemen, including representatives of the press, on the invitation of the Manchester and District Edison Electric Light Company, visited Messrs. Rhodes and Sons' Mills, at Hadfield, and inspected there what is said to be the most extensive electric light installation in any private establishment in the country. These mills contain 73,566 spindles and 1,300 looms, and they are lighted throughout by means of Edison-Swan incandescent lamps, of which there are nearly 1,500. They are of the 16 candle-power type, with brass socket-holders, and each provided with a porcelain shade. The conductors, consisting of copper cables and wires of 99 per cent. conductivity, are insulated with a double covering of pure india rubber, well protected with prepared cotton and braided externally; except where they drop to the lamps, they are throughout the mill encased in woodwork. Each room is provided with switches to control the lights as required; these switches are placed near the entrance in convenient positions, and are mounted on slate bases. Safety fuses are inserted in the various circuits and branch wires. The current is supplied from two Edison-Hopkinson dynamos, each capable of an output of 44,000 watts, equivalent to 750 lamps (110 volts, 400 amperes), at 720 revolutions per minute. They are of the latest Edison-Hopkinson type, with the length of field-magnets still further reduced, and bar armatures. The commutators are built up of 47 bars of copper, insulated with mica, and are readily detachable from the armature. There are three brushes on each rocking arm, each separately adjustable with spring forward thrust and hold off catch. The armature bars have a section of 0·106 square inch, and hence the load is three amperes per square millimetre. The dynamos are compound wound, but owing to the great strength of the magnet field and small disturbance caused by the armature 12 convolutions of series coils is sufficient to secure perfect compensation for the whole range. The following are the particulars of the resistances:—Armature, 0·00645 ohm; series coils, 0·0013 ohm; shunt coils, 17·4 ohms, showing an electrical efficiency of 96 per cent. and a commercial efficiency of from 94 to 95 per cent. The dynamos are driven by a horizontal engine, specially designed and constructed by Messrs. Mather and Platt, of Salford, for the purpose. This engine is of the high-pressure condensing type, with a single cylinder 23in. diameter, 30in. stroke, intended to run at 100 revolutions per minute, and to work with a boiler pressure of 80lb., and under these conditions will indicate about 170 horse-power. After the company had inspected the mills Mr. William Rhodes, on behalf of his firm, expressed his pleasure in having had the opportunity of showing those persons over the mills, and pointed out that the electric light installation was the largest yet made in a cotton mill, so far as he was aware, and he had no hesitation in stating that it had given him every satisfaction by the very efficient manner in which it had been carried out. His workpeople found the light much better than gas, and during the past season a fewer number had been absent through ill health than in any previous years. The cost was just about the same as gas, but they had a better, pleasanter, and healthier light to work by. This was responded to on behalf of the Edison Company by Mr. Freemantle. The whole work has been carried out under the direction of Mr. Williamson, manager of the Edison Company.

Electric Lighting at the Manchester Jubilee Exhibition.—The arrangements for the entire lighting of the Exhibition buildings and grounds are now complete. The Secretary of the Electric Lighting Committee sends us the following:—The main buildings, with the gallery of approach and the Botanical Gardens, will be illuminated by 353 arc lamps; while the machinery in motion section, with its annexe and grounds, will require in addition 193 lamps, making a total of 546 arcs of 2,000 candle-power each, and requiring engines capable of exerting a total of 1,000 indicated horse-power. The installation will be carried out by the Anglo-American Brush Company, of London, who were the successful tenderers. The Fine Art Galleries will be illuminated by 1,650 16 candle-power Edison-Swan glow lamps, arranged on the roof principle, and fitted with porcelain reflectors. Each separate room will be supplied from at least three distinct circuits. Messrs. Mather and Platt, of Salford, have very generously placed the entire generating plant for this section at the service of the Executive Committee. It comprises two vertical engines and four dynamos of the well-known "Edison-Hopkinson" type, and two dynamos of the "Manchester" type. In the Botanical Gardens and "Old Manchester and Salford," with the adjoining "Palm House Dining Room," electric lighting on a very large scale is contemplated. Messrs. Galloway and Sons have been entrusted with the working arrangements connected with the fairy fountains. The entire system of water pipes, electric connections for the projector lamps fitted underneath the surface of the water, and the signals for the changing of the various coloured effects, will be controlled from a manipulating tower. We understand that Messrs. Galloway have made several important additions and improvements in this style of ornamental lighting, and that the fairy fountains at the forthcoming Exhibition will be on a more complete scale than at the Inventions and Colonial and Indian Exhibitions. The quaint buildings of "Old Manchester and Salford" will require 600 20 candle-power Edison-Swan lamps placed throughout the shops pertaining to the various handicrafts, and for street lighting by old-fashioned horn lanterns. The windows in the chapel and old public buildings being of fine stained glass, the lamps will be arranged so as to give a fine effect of coloured light, while two large arc lamps, suspended on a mast 100ft. high, will throw a diffused moonlight effect on the streets below. The palm house dining room will be one of the finest pieces of decorative lighting in the Exhibition; 750 glow lamps will be hung amongst the foliage. For the lighting of the fine art galleries, the palm house dining room, and "Old Manchester and Salford," the tender of the Manchester District Edison Company has been accepted. A comparison of the entire electric display with what has been done in London will show the importance of the illuminations at this Exhibition. At the Colonial and Indian Exhibition 423 arc lamps were in use, each lamp on an average lighting a floor space of 1,270 square feet. In the Manchester Exhibition it has been arranged that all the internal lighting shall, with the exception of the picture galleries, be done by means of 476 arc lamps, each lamp having only 850 square feet of floor space allotted to it. The incandescent lamps will be far in excess of the number used for lighting the vestibules, the Indian Palace, and other parts of the Colonial and Indian Exhibition just closed. The numbers are as follows:—London, internal lighting, as above, 1,851 lamps. Manchester, picture galleries, 1,650 lamps; "Old Manchester and Salford," 600; palm house dining room, 750; total 3,000. The arrangements described have been made by Mr. William A. Bryson, electrician to the International Exhibition, held in Edinburgh last year, who has been appointed electrician to this Exhibition, and the installation will be under his control.

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(*Continued from page 233.*)

The next step in the improvement of the armature was so to arrange matters that the currents when sent in the same direction through the circuits by means of the commutator should be continuous instead of intermittent, and subject to as small variations in strength as possible. This condition is secured in the Siemens-Alteneck armature, in which a length of wire is wound longitudinally around an iron cylinder, as in the armature just described, only, instead of all the turns of wire being parallel to one plane the wire is wound in different azimuths. At the end of a certain number of turns, depending upon the size of the armature and the thickness of the wire, a connection is made with a strip of copper which forms part of the commutator. That these connections may be symmetrically arranged all round the armature the wire must be wound in two layers on the core. Finally the ends of the wire are connected together, and to the same strip of copper in the commutator. The commutator thus formed consists of a number of strips of copper insulated from one another, and arranged round a cylinder so that a pair of copper wire "brushes," pressing upon the surface of the cylinder at opposite extremities of a diameter, may come in contact with each copper strip in turn as the armature revolves. The wires which convey the current to and from the external circuit are connected with these brushes. The armature is made to revolve in a cylindrical space between the poles of a magnet, and the lines of force pass radially across the wire into the iron core of the armature from the north pole of the magnet, and similarly from the iron core to the south pole on the other side. If we confine our attention to a particular turn of wire, it is clear that as it revolves there will be an electromotive force in it in one direction during one half of a revolution, and in the opposite direction during the other half, the electromotive force being reduced to zero, and changing sign, when the turn of wire is perpendicular to the line joining the poles of the magnet. Hence, in the whole armature at any instant there will be an electromotive force in one direction (relative to the wire) around one half of the turns, and in the opposite direction around the other half of the turns of wire, while there will be two points in the wire which divide the former half from the latter half, and in the wire in the neighbourhood of these points there will be no electromotive force. When the brushes are properly adjusted on the commutator it is these points which are at any instant in connection with the brushes. If we call the points A and B, then in one half of the wire there is an electromotive force from B to A, and the other half of the wire there is also an electromotive from B to A, since in the two halves the electromotive forces are in opposite directions in the circuit of wire. Thus, a current will be sent from B to A through each half of the armature, and from A to B through the external circuit. As the armature revolves each turn of wire passes from the one half to the other as it passes the "dead-point," or that portion in which there is no electromotive force induced in the wire. Since the electromotive force between A and B is always the sum of the electromotive forces in the several turns of wire, it will experience only very slight fluctuations as the armature revolves. When the armature is revolving at a high speed, the iron core becomes strongly magnetised and produces its own field of force, so that the actual field in which the armature revolves is due to both the core and the field magnet, and thus the lines of force are distorted, being strained, as it were, in the direction in which the armature revolves. In consequence of this the position of a turn of wire in which there is no electromotive force induced is not symmetrical with respect to the magnet, but is deflected in the direction of the motion of the armature, and it is therefore necessary to give a corresponding amount of "lead" to the brushes of the commutator.

To avoid induced currents in the iron core a quantity of iron wire wound upon a wooden bobbin is used in place of a solid iron cylinder. As the induced electromotive force acts parallel to the axis of the cylinder, the currents set up in the iron have to pass from one strand of wire to another, and thus meet with great resistance.

In the large Edison machines stout copper bars are employed instead of wire in the armature, and alternate discs of iron and paper, instead of iron wire, serve, as above mentioned, for the core. In other respects the Edison armature is very similar to the Siemens-Alteneck armature; but the arrangements of the field-magnets are different in the Edison and Siemens machines.

The Gramme armature consists of a ring of iron wire, around which the copper wire is wound in a continuous circuit. Thus, all the strands of iron wire forming the ring pass through every turn of the copper conductor. At regular intervals along the copper coil, connections are made with strips of copper forming the commutator, as in the Siemens-Alteneck armature. The armature revolves in a cylindrical space between the poles of the magnet. Most of the lines of force of the magnet pass radially from one of the pole-pieces across the copper wire, and into the iron wire of the armature, and similarly from the iron wire into the other pole-piece. Hence, as the armature revolves, the copper wire which is on the outside of the iron ring will be cutting the lines of force of the magnet in one direction during one half of each revolution, and in the opposite direction during the other half. As in the Siemens-Alteneck armature there will be two points in the wire in the neighbourhood of which there will be no electromotive force, and these points will be in connection with the outer circuit, through the commutator. If these points are denoted by A and B, one half of the wire will be transmitting a current from B to A, and the other half will be doing the same, though these two currents will clearly be in opposite directions in the coils of the armature. Both in the Gramme armature and the Siemens-Alteneck armature the current in the external circuit is supplied by separate halves of the revolving coil, one half of the current flowing through one half of the coil, and the other half of the current through the other. Hence, the resistance of the armature is only one quarter that of the wire with which it is wound. The principal objection to the Gramme armature is that all the copper wire which is inside the iron ring cuts no lines of force, and while it introduces resistance into the armature it is inoperative as far as the production of the current is concerned.

In magneto-electric machines, or those in which the magnetic field is maintained by a permanent steel magnet, the electromotive force in the armature is proportional to the speed of rotation, provided that the speed is not sufficient to sensibly distort the lines of force on account of the induced magnetism when an iron core is employed in the armature. When this is the case, the electromotive force increases in a somewhat lower ratio than the velocity of the armature. When no iron is employed in the armature, the electromotive force may be taken to be proportional to the speed for all velocities, and the only limit to the electromotive force, and therefore to the current which may be obtained with such machines, if sufficient power be applied, is fixed by the over-heating of the armature, or by its flying to pieces in consequence of the stresses induced by the high speed of rotation. When an iron core is employed, the magnetism in the core produces such changes in the directions of the magnetic lines of force, more and more lead having to be given to the brushes of the commutator as the speed is increased, that the magnetic field at length becomes so much weakened that nothing is gained by further increasing the speed of rotation. Even when no iron is employed in the armature, the current in the coils of the armature acts inductively upon the field-magnet, tending to diminish its magnetism, and as no steel magnet is altogether proof against induction, the current must cease to be proportional to the speed when increased to a very great extent. By employing very high speeds and a very small amount of wire on the armature the magnetic moment of the armature, and therefore the distortion of the magnetic field, may be made very small and very little lead will then be required by the brushes.

Wilde's machine consists of two distinct generators. The first is a small generator provided with a permanent horseshoe magnet and a Siemens armature, and may be called the

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exciter. The second is a much larger machine furnished with a powerful electro-magnet, and an armature similar to the other, but much larger. The current from the armature which revolves between the poles of the permanent magnet serves simply to excite the electro-magnet of the larger machine, and the current from the armature of this latter machine passes through the external circuit.

Wheatstone, Siemens, and Varley simultaneously suggested that the residual magnetism of an electro magnet might be made available for the production of a feeble current, which, being transmitted in the proper direction round the coils of a magnet, would increase the magnetism, the increased magnetism in turn enabling a stronger current to be produced, and each reacting upon the other until at length the electro-magnet became saturated, or the rate at which electrical work was being done reached the limit of the power of the agent driving the machine. Generators of this class are properly called dynamo-magneto-electric machines, but more generally, dynamos. Their action resembles that of the replenisher, or of other electric machines which work on the "compound interest principle," only it is electro-magnetic induction instead of electrostatic induction upon which their efficiency depends. In all these machines the commutator attached to the armature sends the current always in the same direction round the coils of the field-magnets. The commutators of the Gramme and Siemens machines have already been described. Four classes of dynamos (properly so called) may be enumerated. (I.) Those in which there are two armatures, one of which is employed solely in exciting the field-electro-magnets, while the other sends its current round the external circuit. Some Gramme machines intended to send a large current through a small external resistance are constructed on this type, the armature which excites the field-magnets being wound with finer wire than the other. (II.) Those in which the same current passes round the field-magnets and the external circuit in succession. These are known as series dynamos. The Brush machines used in circuit with the Brush lamps are of this class, the machines being so constructed that they may light their full number of lamps when the whole current requisite for the lamps (ten amperes) passes through the magnet coils. When a smaller number of lamps are in circuit, so that the full E.M.F. of the machine is not required, as it is not usually convenient to alter the speed of the armature, a part of current is shunted so as not to pass through the coils of the field-magnets, and thus the strength of the magnetic field and therefore the E.M.F. of the machine is reduced. (III.) Those machines in which the current from the armature is divided, part going through the coils of the field-magnets, and part going through the external circuit. These are known as shunt dynamos. All the continuous current machines which are intended to transmit very great currents through the external circuit belong to this class. In these machines the armature is constructed so as to have a resistance which is very small compared with that of the external circuit, and negligible in comparison with the resistance of the magnet coils. The armature, therefore, behaves like a battery of no sensible internal resistance, and consequently, so long as the speed of rotation of the armature and the strength of the magnetic field are maintained constant, the electromotive force between the terminals of the armature will be practically constant, whatever changes are made in the resistance of the external circuit (within the assigned limits), and therefore in the current through the armature. In such machines a current of from 10 to 100 amperes will generally be sufficient to excite the field-magnets, the actual strength of current required depending on the gauge of the wire employed in winding the magnet coils, while a current of, perhaps, 10,000 amperes may pass through the external circuit, and be employed in lighting a large district. The Edison and Elphinstone-Vincent and many Gramme machines belong to the class of continuous current shunt dynamos. (IV.) The fourth class is a mixture of the series and shunt machines, the field-magnets being wound with two sets of coils, one set being in series with the rest of the circuit, the other forming a shunt circuit. In a series machine the strength of the field-magnets increases with the current in the external circuit, and hence, if the speed of rotation be constant, the electromotive force will increase with the strength of the current. This is an advantage in an electric light installation when all the lamps are at a great distance from the dynamo, and the resistance of these leads is considerable; but generally it is important to preserve the E.M.F. at the terminals of the machine as constant as possible. In a shunt dynamo the current in the field-magnet coils will diminish when that in the main circuit is increased, unless the resistance of the armature is altogether negligible in comparison with that of the rest of the primary circuit. Hence the electromotive force will diminish as the current in the primary circuit is increased. By combining the shunt and series coils, it may be so arranged that the strength of the field-magnets is exactly the same when the current in the circuit is zero, and when it has its maximum value, or any two particular values of the current in the main circuit may be selected and the coils adjusted so that the field-magnets may have exactly the same strength for either of these currents, and the strength of the magnets will then be very nearly the same for intermediate currents. As the current in the series coils, which consist of a few turns of very thick wire, increases, that in the shunt coils, which consist of a great many turns of comparatively fine wire, diminishes, but to a much smaller amount. The increased number of turns of wire in the shunt coils, however, compensates for this difference.

In a series dynamo the resistance of the field-magnet coils should not be greater than that of the armature, and both should be kept as small as possible. In a shunt dynamo the resistance of the armature should be made as small as is consistent with obtaining the requisite E.M.F. at the speed at which the armature is intended to be driven, and without exceeding the proposed dimensions of the machine. The resistance of the shunt coils should then be made a third proportional to that of the armature, and that of the external circuit when the resistance of the external circuit has the value for which it is desired that the dynamo should work with the greatest economy.

Alternating current dynamos or distributors must, of necessity, be provided with separate exciters, which may be dynamos belonging to any of the above classes.

(To be continued.)

INCANDESCENT LAMP MANUFACTURE.—V.

BY J. SWINBURNE.

Amyloid Carbon. (*Continued.*)

Many substances besides sulphuric acid and zinc chloride will gelatinise thread. Of those that act by their affinity for water, phosphoric acid is the best known. Phosphoric acid can be made to act, but it is uncertain what the exact conditions are. There are three phosphoric acids; metaphosphoric, pyrophosphoric, and orthophosphoric. Of these, the first seems to be the only one that acts. The glacial phosphoric acid of commerce is metaphosphoric acid. It can also be made by allowing phosphoric anhydride to absorb water from the air slowly, so as not to get hot. The solution so obtained will act on cellulose as sulphuric acid does, only very much more slowly. The solution must not be made rapidly, or heated, otherwise orthophosphoric acid is formed, and this will not act. The solution formed by dissolving fused or glacial phosphoric acid in water does not seem to be quite the same as that obtained by letting the anhydride absorb moisture gradually.

The strongest hydrochloric acid that can be got acts on cotton and partly parchmentises it, but it does not form either a good gelatinised thread or a good solution of cellulose. It converts the cellulose into dextrin too quickly. Hydrochloric acid is a very useful addition to zinc chloride solution, and perhaps to other chloride solutions, but does not work well alone.

Calcium chloride does not parchmentise cellulose, even when a hot concentrated solution is used. Magnesium chloride is also useless, though it has a very strong affinity for water. It seems to form a hydrated salt which renders the solution solid. The solution in hydrochloric acid is also useless.

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Aluminium chloride has a very strong affinity for water; in fact, it hisses like phosphorus pentoxide when thrown into water, but it does not act on cellulose. This may show that the action is not due to the mere abstraction of water from the cellulose, but that there are some other conditions to be fulfilled. This is also shown by the action of zinc chloride solutions. A very strong solution does not act on cellulose, though it parchmentises or gelatinises it when diluted to a certain strength.

Messrs. Wynne and Powell mention zinc bromide, zinc iodide, bismuth chloride, and bismuth bromide as acting on cellulose. Hydrofluoric acid, when very strong, acts on cellulose, but it is difficult to get the acid strong enough, and it is very troublesome to work with, as it attacks glass vessels, and has to be kept in gutta percha, and as it gives off very irritating and unwholesome fumes.

Mr. Crookes patented carbons made by the action of what is generally known as Schweitzer's reagent, or cuprammonia. Cellulose may be dissolved in cuprammonia, or loose textured thread may be merely drawn through it and washed in dilute acid. Cuprammonia does not dissolve the cellulose enough to make homogeneous thread in this way. The amount of liquid that there is room for in the pores of knitting cotton is not large enough to dissolve the cotton, and so the resulting thread is not homogeneous. When dried it looks as if the cotton had merely been soaked in a green varnish. Cuprammonia does not seem to act on cellulose by virtue of an affinity for water, for it still dissolves it when diluted. It seems to form a definite cotton compound with it.

The well-known Willesden paper is made by acting on paper with cuprammonia.

The preparation of amyloid by completely dissolving cellulose in cuprammonia will be described later.

Another method of making thread homogeneous is converting the cellulose into a substitution product which can be gelatinised. If loose textured thread is passed through fuming nitric acid of 1·5 sp. gr., the cellulose is converted into a nitro-substitution product, probably xyloidin. This is apparently partly soluble in the strong acid, so that the thread is gelatinised. It is then washed, and left to soak till all trace of acid is gone. It is then boiled in ammonium sulphide or a protosalt of iron, such as the protochloride, which takes out the nitryl and replaces the hydrogen. The material has then the same composition as the original cellulose. After drying in the usual way the material is cut to size and carbonised. The writer introduced this process in 1883; but it is difficult to manage commercially. The writer has himself made very good carbons by this process; but the carbons made in the factory by it were not good, as they were never properly gelatinised. Fine carbons are easier to deal with than thick ones. The fumes from the strong nitric acid are also very objectionable.

So far amyloid carbons made directly from thread have been described; there are various processes in which the cellulose is completely dissolved, and then precipitated in its homogeneous form, and it is probable that the resulting carbon is better when the fibrous cellulose is completely dissolved.

Crookes was the first to describe the manufacture of carbons from dissolved cellulose; and Weston soon introduced his own ingenious process into commerce.

Crookes, in his patent, proposes to dissolve cellulose in cuprammonia, and to pour the solution into a vessel with an accurately levelled bottom. The ammonia and water are to be allowed to evaporate, thus leaving a green film of amyloid. This film is to be washed, and soaked in dilute acid to extract the copper, and then dried between sheets of blotting paper under pressure. Perhaps the best way of preparing cuprammonia is as follows:—Caustic soda is added to a solution of copper sulphate. The green precipitate is then washed with water, and is then shaken up with the strongest ammonia. The ammonia does not dissolve very much of the precipitate, but it forms a very deep blue solution. The clear blue solution can be decanted off quite easily, and the precipitate treated with more ammonia.

When cotton wool is stirred into this solution it dissolves completely if there is excess of cuprammonia. If more cotton wool is added, it does not dissolve as, for example, pyroxylin does in nitro-benzol, but the cuprammonia takes up as much cellulose as it can, and the rest remains with its fibre unattacked. A thick jelly cannot, therefore, be prepared by adding more cellulose to a thin solution. The solution of cellulose in cuprammonia is thin, and contains little cellulose. The sheets of amyloid made by evaporating the solution down were shown by Mr. Crookes at the Inventions Exhibition. There is difficulty in drying such sheets flat, however, as they are apt to wrinkle up through uneven contraction. The thin sheets of amyloid are cut into strips of the right length and width by punches, as already described.

Weston's process is as follows:—Cotton wool is first treated with nitro-sulphuric acid of the right strength to convert it into pyroxylin. The pyroxylin is washed and dried and made into collodion. Full particulars of the manufacture of collodion are to be found in Abney's and other treatises on photography. The collodion, consisting, of course, of a solution of pyroxylin only, is poured into shallow flat-bottomed dishes, and allowed to dry, so that thin, horny sheets of homogeneous pyroxylin are formed. The blanks may then be cut, or the material may be subjected to the next process, or reduced first. The pyroxylin contains too much oxygen to leave good carbon, so it is treated with ammonium sulphide, which brings it back to amyloid. Weston calls the material *tamidine*, and it is said to make very good lamps. Solution of cellulose in zinc chloride might no doubt be treated in a similar way.

Swan has taken out a patent for squirted tamidine. Pyroxylin is dissolved in acetic acid, or in ether and alcohol, and the solution is placed in a vessel with a nozzle at the bottom. The solution is then forced through the nozzle by means of a compressing air pump. As the liquid issues slowly from the nozzle it comes in contact with alcohol, which causes it to set, and it coils in a continuous thread at the bottom of the vessel. This thread is then washed, and treated with ammonium sulphide in the usual way. Ammonium sulphide is apt to deposit sulphur in the thread; and iron protochloride is perhaps better, though this salt sometimes discolours the thread. Material made by this process was exhibited at the Inventions Exhibition. There appears to be great trouble in getting the process to work well on a manufacturing scale. The Edison-Swan Company apparently use the sulphuric acid process still. One source of trouble is the indeterminateness of composition of pyroxylin. There are several nitrosubstitution compounds of cellulose, and a mixture of these is formed. Some are more soluble than others in ether and alcohol and acetic acid. Small quantities of more or less completely dissolved pyroxylin coming through the nozzle are apt to make the issuing thread irregular, and the solution, though apparently smooth, may really contain pyroxylin in the form of broken jelly, which distorts the issuing stream.

In his patent Swan mentions nitroglucose also. This does not appear a promising material to work with, and it would be interesting to know if threads have been made of this uninviting substance.

THE ELIESON ELECTRIC TRAMWAY SYSTEM.

On Thursday, the 20th inst., a party of about 60 gentlemen, among them being the Earl of Galloway, Marquis of Tweeddale, Lord Sackville Cecil, Sir William Thomson, Sir James Anderson, Mr. John Pender, Mr. J. Wickham, Mr. S. Hamilton, Mr. Magnus Volk, &c., visited the Stratford tramway station, and inspected the machinery and cars, and afterwards made a trip of about 2½ miles each way in a pair-horse car, drawn by an Elieson locomotive, some of the party riding on the latter.

Mr. Elieson explained the construction of his accumulators, which are made with a lead grid 9in. by 8in. In each hole is placed a small flat coil of thin lead and asbestos paper, no red lead or similar substance being used, the battery being of the Planté type. During the formation the plate extends about a quarter inch in each direction, and there seems no liability of the coils falling out or injury arising from the bending of the plates. It is estimated that the maximum effect of the battery will not be reached in less than three years.

The party next inspected the car machinery, and although

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everything works well there is some difference of opinion as to the mechanical arrangement of the gearing, and it would be preferable to use some of the underfriction clutches in the gearing instead of the old-fashioned toothed clutch, which, if thrown into gear suddenly—which in practice would be sure to happen—would cause an utter breakdown. Such a contingency as this should be provided against as far as possible, and an improved arrangement of clutches would obviate this. As now arranged, the reversal, which is mechanical and not electrical, has to be done with extreme caution, a small amount of current being put on so as to turn the clutches into the right position for engaging.

The effective result of the locomotive is very satisfactory when on the level, and drawing a pair-horse car and a total complement of 60 passengers. Twenty-five amperes of current were used, and on starting 75 amperes, the E.M.F. being 189 volts (90 accumulator cells). The charge lasts for four hours, but in case of necessity it may be used for five hours, but of course at the expense of efficiency.

The car mounted the gradients on the route without difficulty, and the trip was satisfactory in every way.

There are four or five cars ready for use, and everything is ready for work as soon as the necessary powers are obtained, the delay having been caused by the dissolution of Parliament last year.

1886.

Before continuing this subject we are asked to correct the figures given on p. 238, line 6, where $1\frac{1}{2}$ should read 2 horse-power. The error is not ours, as we took the figures supplied us. Also Fig. 23 is called the A type of dynamo, and not the G. T. type.

We have previously referred generally to the Kapp dynamo as constructed by Messrs. ALLEN & Co., and we return to this

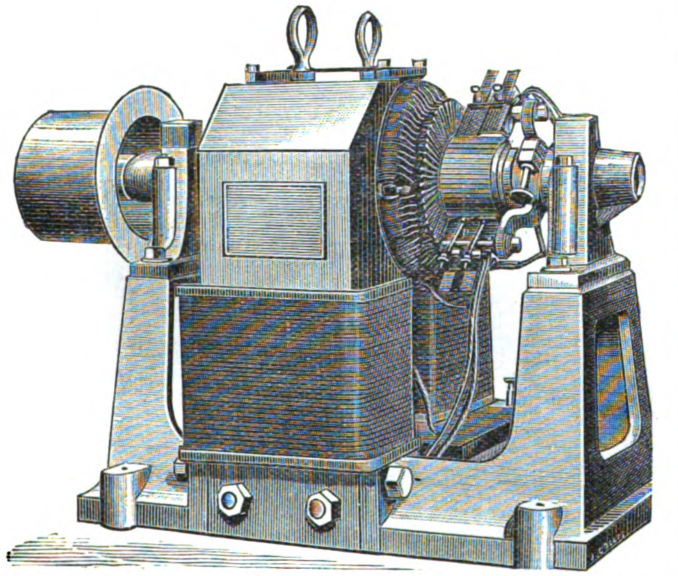

FIG. 27.—The Kapp Shunt Dynamo, giving an output of 9,600 watts.

dynamo in order to give some details. The machine illustrated in Fig. 27 is a shunt dynamo to give an output of 9,600 watts, or 9·6 units. This output is obtained with a current of 120 amperes, at an E.M.F. at terminals of 80 volts, the normal speed for this output being 435 revolutions per minute. The electrical efficiency is given as 90 per cent. The field-magnets are of the single horse-shoe type, made of wrought iron annealed. The resistance of the shunt coils as connected is 16 ohms, and the current 5 amperes. The turns are 3,240, and ampere turns 16,200, involving a loss of 400 watts. The armature is the ordinary Kapp armature, with an axial length of 13in., a diameter of 13in., and a radial depth of 2·5in.; the number of lines of force per square inch cross sectional area of iron, according to the well-known Kapp formula $N = \frac{1,000,000\,E}{n\,S\,A} = 20{\cdot}5$; the peripheral speed of armature at the normal speed is 1,500 feet per minute. The dynamo has two brushes on each side, separately adjustable. The diameter of pulley is 10in., and the breadth 6in., and the number of pieces in the commutator 72.

Messrs. ELWELL-PARKER have rapidly come to the front rank of electrical engineers, and their dynamos and motors are

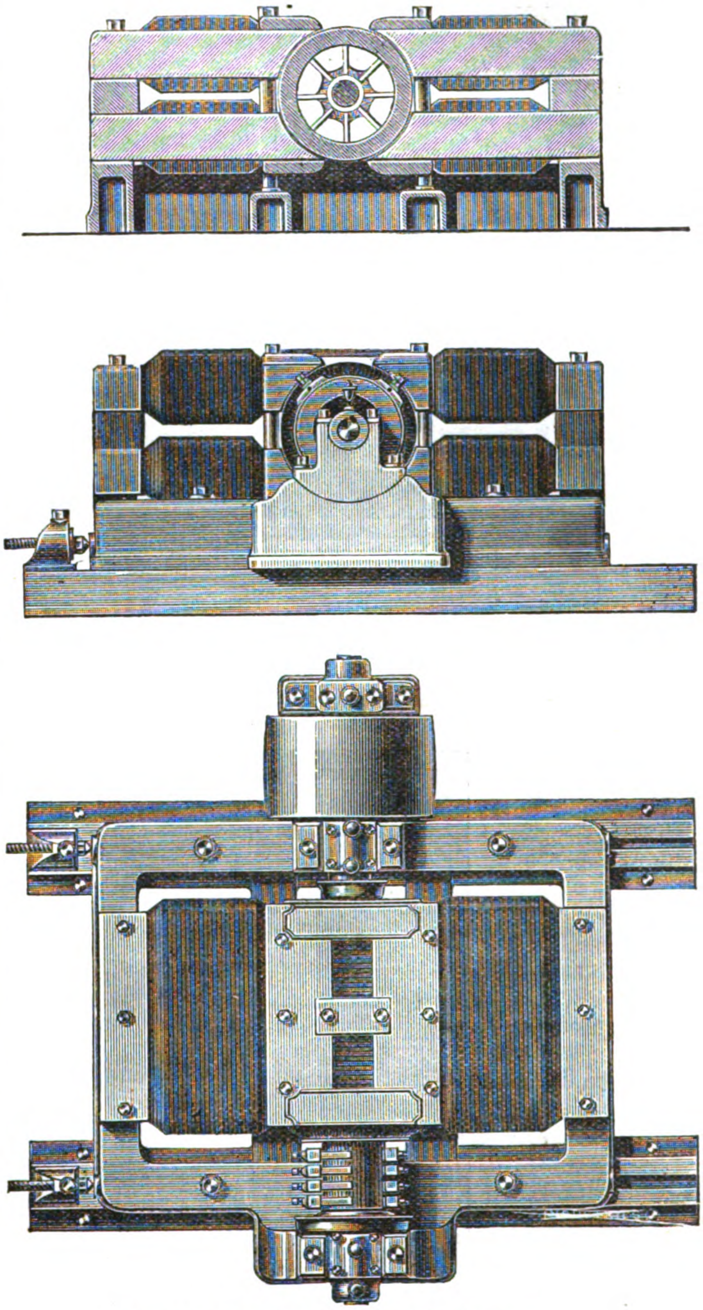

FIG. 28.—Elwell-Parker Four-Pole Dynamo.

being largely used. We are indebted to our contemporary *Industries* for the accompanying illustrations and information of two-pole and four-pole dynamos as constructed by this firm: The field-magnets in the vertical two-pole machines are similar in type to those used in the modern Edison-Hopkinson dynamo; that is to say, the pole ends of the magnet are placed on a non-magnetic base, and the limbs, as well as the top yoke, are made of soft wrought iron, specially annealed. Only two exciting coils are used, one on each limb. This dynamo is intended for use with a gas engine, and a very heavy fly-wheel has been provided to steady the motion, the armature and a short piece of shaft, with fly-wheel and driving pulley, being supported on one cast-iron bed. The machine gives

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100 volts and 200 amperes at 950 revolutions per minute. The armature is wound with 104 turns of silk-covered copper wire, and has a resistance of ·021 ohm, whilst the resistance of the shunt is 55·9 ohms. From these data it follows that the current in the shunt is 1·8 ampere, making the total armature current 201·8 amperes, which corresponds to a loss of 4·25 volts and 855 watts.

The loss in the shunt is 182 watts, whilst that in the main coils is 200 watts, bringing up the total losses inside the machine to 1,237 watts. This, compared to the output of 20,000 watts, gives an electrical efficiency of 94 per cent. The four-pole dynamo, illustrated in section, elevation, and plan, is intended for driving by a steam engine, and is therefore not provided with a heavy fly-wheel. The arrangement of field-magnets is somewhat similar to that of the machine shown by Messrs. Elwell-Parker at last year's Inventions Exhibition; but the magnet limbs, instead of being inclined, are placed parallel to each other, and are generally made of larger cross section, whereby the output of this machine has been considerably increased. The machine is shunt wound, and is arranged to run at 450 revolutions per minute. The external E.M.F. is 130 volts, and the normal output of current is 385 amperes. The armature is wound with a single layer of silk-covered copper wire in 196 turns, and has a resistance of ·015 ohm. To collect the current a system of four sets of brushes is employed, opposite brushes being at the same potential. The magnets are compound wound, and have a resistance of 15 ohms. The electrical efficiency is given as 93·5 per cent. The machine measures in the direction of the spindle 6ft. 4in., and in the direction of the magnets 5ft. 5in., exclusive of its sliding bed, whilst its total height is 2ft. 4in. The total weight is four tons, being at the rate of 1·2cwt. per horse-power developed in the external circuit.

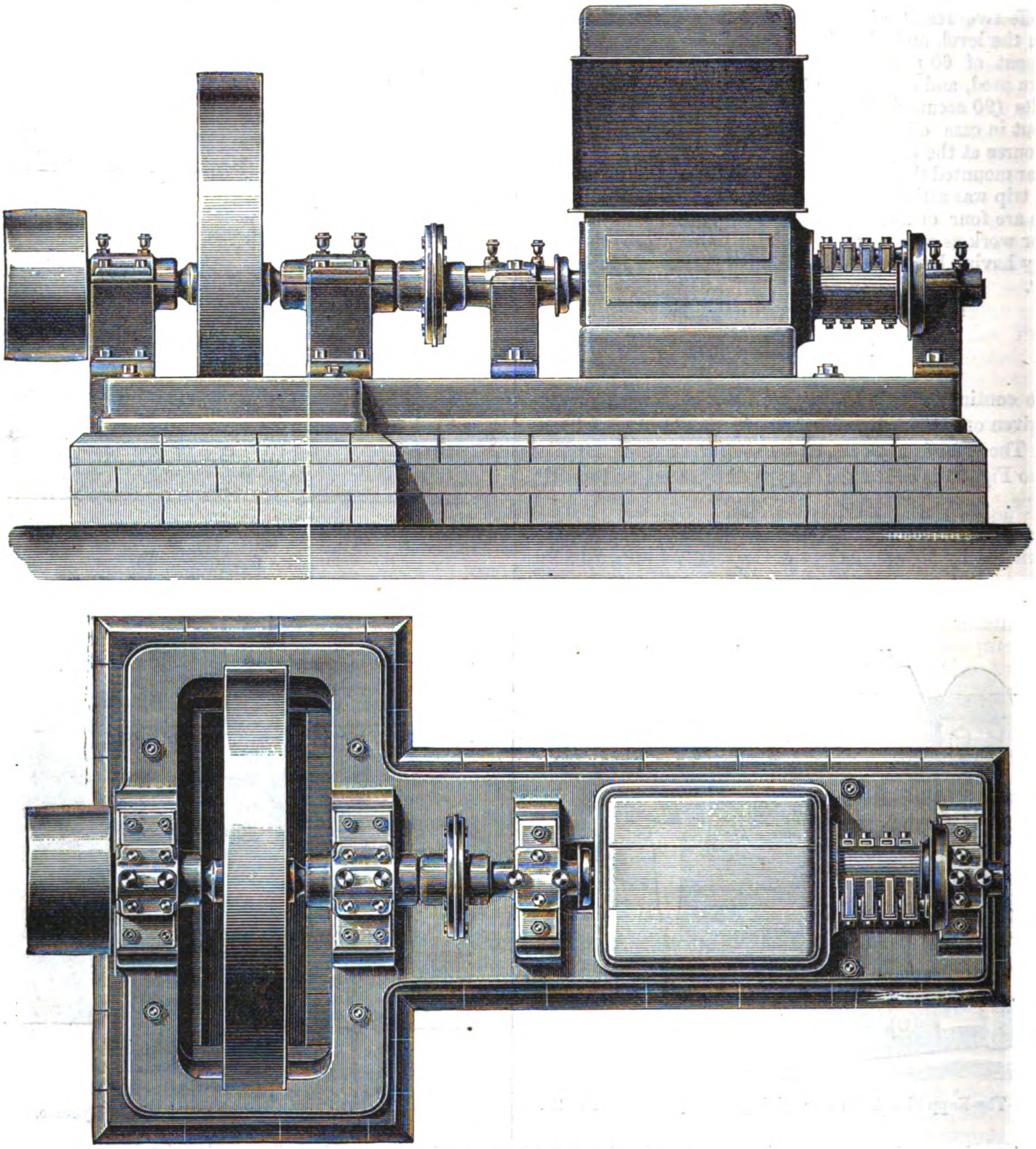

Fig. 29.—Elwell-Parker Two-Pole Dynamo.

The Schaffhouse Falls.—The famous falls of Schaffhouse on the Rhine are to be turned to account by being utilised for the production of electricity by a company which is about to undertake the production of aluminum upon a large scale. We are not told whether it is intended to employ the Cowles process, or whether the dynamos are merely to be employed for lighting purposes. According to *La Lumière Electrique* the work has already been in progress for some weeks.

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MERCURY IN THE MAGNETIC FIELD.

At the French Academy, on the 7th inst., a note was read by M. H. Dufour describing some experiments which tended to prove that the internal coefficient of friction of mercury diminishes when the metal is placed in a magnetic field. This was shown in the following manner:—We know that if a liquid be caused to flow through a capillary tube its velocity will vary directly as the pressure, directly as the fourth power of the diameter of the tube, inversely as its length, and finally inversely as a coefficient depending on the internal friction of the liquid. Now, if mercury is allowed to flow from the end of a capillary tube which is placed between the poles of an electromagnet, the length of the parabola described by the issuing liquid *increases* when the magnet is excited, this proves that the velocity of the flow is augmented, and as all other conditions are unaltered the effect must be due to a diminution in the internal friction of the mercury.

LIGHTING PLANT FOR INDIA.

Messrs. Paterson and Cooper have recently supplied several sets of electrical apparatus for use in India, one of which we

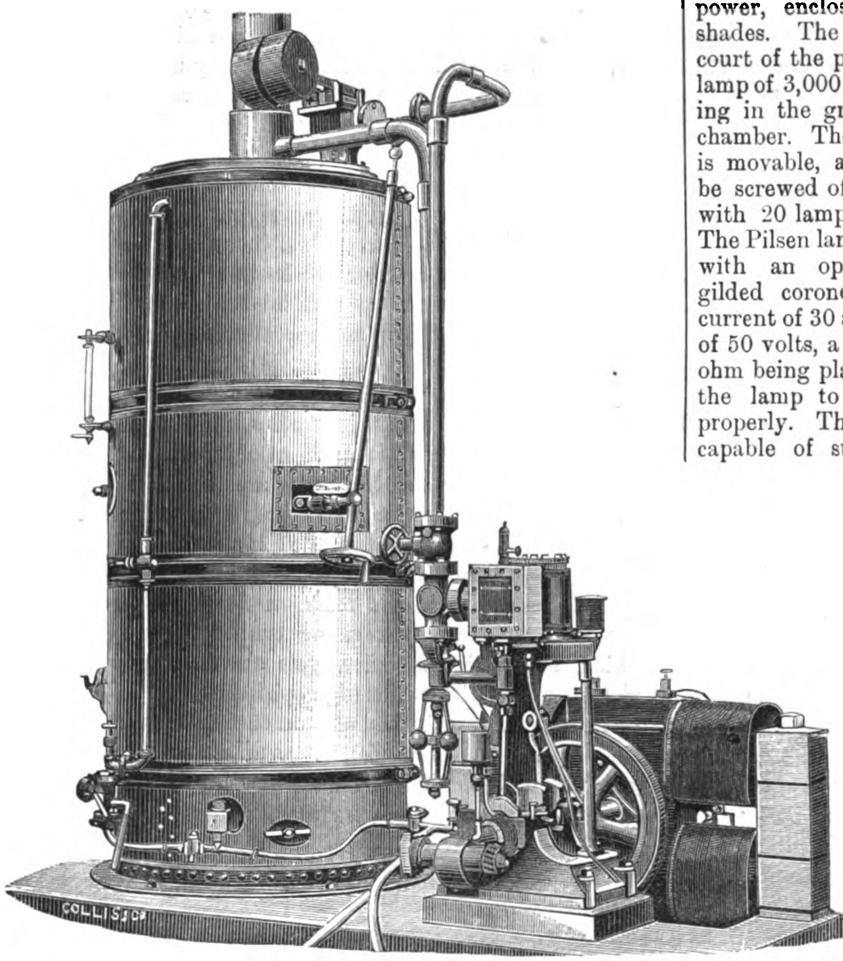

Fig. 1.—Phœnix Dynamo coupled direct to a Gwynne Engine.

herewith illustrate. Our kind friends in the firm tell us that our illustrations are deficient in respect to Fig. 1, which should show the base plate entire, and Fig. 2 the pedestal upon which the female figure stands. We plead in excuse that we could see nothing new in base plate or pedestal, and are quite willing to bear testimony that they are necessary for the due performance of the plant. Joking apart, we think the whole is an exceedingly good example of a practical, portable plant, and to judge from the photograph from which our engraving is taken the cluster is charming.

The generating plant consists of a Phœnix dynamo coupled direct to a Gwynne Invincible engine. The dynamo and engine, with the boiler, are mounted on a strong cast-iron bed-plate. Besides the feed pump driven by the engine an injector is fitted on the boiler, so that in case of accident to one or other of the feed-water appliances no stoppage is incurred. The engine cylinder is 4½in. diameter, with 4½in. stroke, the speed of working being 400 revolutions per minute. At this speed the dynamo generates a current of 50 amperes, at an electromotive force of 65 volts. The lamps used are 60-volt 20 candle-power incandescent. The steam pressure is 80lb. per square inch.

The female figure is of bronze, and was executed by a Parisian artist. It stands on a pedestal of black marble, and holds aloft a cluster of 50 lamps of 20 candle-power, enclosed in tulip-shaped shades. The figure stands in the court of the palace, while a Pilsen lamp of 3,000 candle-power is hanging in the great hall, or council chamber. The cluster of 50 lamps is movable, and the bracket can be screwed off to allow of another with 20 lamps being substituted. The Pilsen lamp, which is provided with an opalescent globe and gilded coronet (Fig. 3), takes a current of 30 amperes at an E.M.F. of 50 volts, a resistance of half an ohm being placed in the circuit of the lamp to enable it to feed properly. The generating plant is capable of supplying current for the arc lamp and the cluster of twenty lamps at the same time, or of supplying the current for the cluster of fifty lamps alone.

We are informed by Messrs. Paterson & Cooper that the effect produced by the electric light, combined with the rich Oriental colouring, is, in the language of the poet, of the most gorgeous description, and has a most pleasing effect.

Messrs. Paterson and Cooper also inform us that a smaller plant combined on the same bed-plate, in which the dynamo is belt-driven, has also been supplied for the lighting of another Indian Palace.

Fig. 2.—Figure and Cluster.

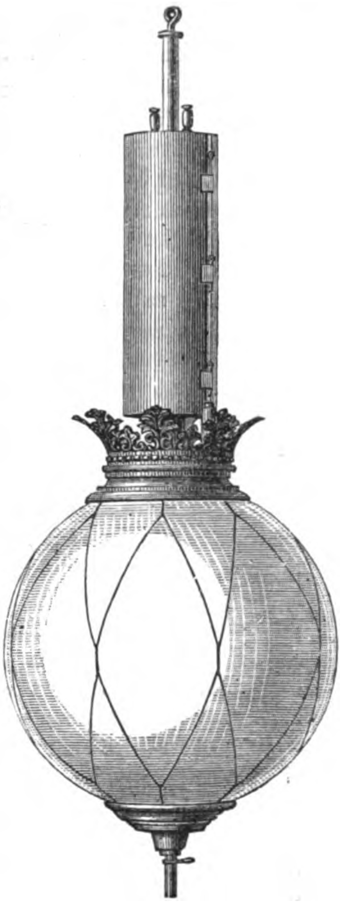

Fig. 3.—Pilsen Arc Lamp.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes 249
Elementary Electricity and Magnetism—II. (Continued.) 254
Incandescent Lamp Manufacture.—V. By J. Swinburne 255
The Elieson Electric Tramway System 256
Retrospect of the Past Year. (Continued.) Illustrated. ... 257
Mercury in the Magnetic Field. 259
Lighting Plant for India. Illus. 259
THE ELECTRICAL TRAMWAY AT BRIGHTON 260
Correspondence 261
Life of Incandescent Lamps ... 262
Recent Practice in the Edison System of Distribution. Illus. 263
Primary Batteries. By Sidney F. Walker. (Concluded.) ... 264
The Anglo-American Telegraph Company 266
Physical Society 267
Legal Intelligence 267
Companies' Meetings—
The Eastern Telegraph Company 270
The Direct United States Cable Company.. 271
The New Telephone Company 274
The Cuba Submarine Telegraph Company 274
India Rubber, Gutta Percha, and Telegraph Works Co..... 274
Companies' Share List............ 274

ANSWERS TO CORRESPONDENTS.

MR. J. W. GREEN.—(1) *Quadruplex telegraphy is fully explained in Preece and Sivewright's "Telegraphy."* (2) *The two expressions you give are identically equal; the second form is only another way of mathematically expressing the same thing.*

THE ELECTRICAL TRAMWAY AT BRIGHTON.

The disaster which, through the fury of the elements, lately inflicted such a heavy loss on Mr. MAGNUS VOLK, the proprietor of the "Marine Electric Railway" at Brighton, has been followed by another, due to the mere wilfulness of human beings, which almost threatens him with ruin. Just as he had made good the damage done to his property by the storm which carried away a great portion of the Brighton beach, and was steadily recovering from the pecuniary injury he had sustained, somebody gets himself pitched off a bicycle, and mulcts Mr. VOLK in heavy damages for being the innocent cause of the mishap. But this is not all. It is pretty well known that a certain section of the community of Brighton are, for reasons not difficult to understand, very unfriendly towards the Marine Railway; and there is ground for suspecting that they have had a hand in encouraging, if not actually promoting, the legal proceedings recently taken against it. Certain it is that the anti-tramway clique have eagerly seized the occasion to apply for an injunction against the proprietor; and, if the prejudices of the inhabitants can be worked up to the required pitch, there is a probability that those harmless and enjoyable rides along the Brighton beach on Mr. VOLK's electric railroad will come to an untimely end.

We need not go far to account for this opposition. During the whole four years this electric line has been at work Mr. VOLK has had to fight against the prejudices and the selfish interests which felt themselves aggrieved by his novel undertaking. People of very fastidious tastes—and there are plenty such at this fashionable watering-place—hate the very name of a tramway; and although Mr. VOLK's tramroad is hidden away unostentatiously under the cliffs, and his tramcars are of the modestest dimensions, they are an unpardonable offence to supercilious loungers who ride only in a carriage and pair. Then, again, the Electric Railway is, as everybody knows, very popular with the people who visit Brighton for the day; and as anything that lends encouragement to the cheap-tripper is obnoxious to the residents of the place, who would like to make it an exclusively aristocratic resort, Mr. VOLK and his innovation have been eyed with ill-will from the very first. These people, together with others, whose interests in the affair are of a different kind and need not be specified here, have been waiting apparently for some opportunity to deprive the Brighton beach of one of its most attractive features; and they have now found it. What the cruel waves failed to do, a friendly bicyclist has very nearly accomplished by a mere turn of the wrist. The storm of last October was rather calculated to excite commiseration; the accident a few weeks later has served to evoke an outburst of unpopularity which may prove overwhelming.

The flimsiness of the pretext which is now laid hold of will be seen from the report of the legal proceedings, the substance of which we print in another column. By the side of one portion of the electric tramroad, and separated from it by a wire fence, there is a level carriage drive, chiefly used by carriages, equestrians and cyclists. One of these latter was pursuing his toilsome pleasure along the drive when he overtook a frisky young horse, past which he tried to squeeze on the wrong side. Whether the horse resented this irregularity, as every well-bred animal would, or whether he detested the bicycle, as every sensible animal, both man and beast, should, does not appear. It is almost certain he was not scared by the tram; he was used to it, and, although a native of Brighton, he does not appear to have manifested any of the prevailing prejudice against his electrical rival. But it is quite certain he did start at something, and that he swerved just as the performer on the bicycle essayed to pass, and that the latter got the worst of the inevitable encounter. As the bicyclist was only a boy we are sorry that he was hurt. Had he been a full grown man our feelings might have been different. We have no sympathy to spare for adult imbeciles who jeopardise their own and other people's limbs by acrobatic feats on flywheels in the public highway. And in any case we cannot be sorry when the machine, as in this instance, gets smashed to pieces. Our anxiety is rather about that high spirited horse.

But whatever may be his sentiments in regard to the horse, or the bicycle, or the bicyclist, every unprejudiced person must sympathise with Mr. VOLK in the circumstance that he, as the proprietor of the passing tramcar, has been fined a good round sum, and charged with heavy costs, because a bicyclist has come into collision with a restive horse. That the boy was not following the rule of the road does not seem to have weighed with the judge in this case. The horse having caused the upset, it is assumed, apparently, that the animal's conduct at the moment was due to Mr. VOLK's electric tramcar. For our part, having seen the offending vehicle, we should say that the horse that would shy at it would just as likely shy at a stoneheap; and although we do not presume to argue on a point of law, we venture to assert, as a matter of common sense and common equity, that the fact of a horse taking alarm at a passing vehicle, even if the fact were proved, would not warrant the punishment of the owner of that vehicle because somebody hurt himself running into the horse. It seems to us a case of seeking for somebody on whom to fix

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the blame, and as the horse could not pay damages or testify to its own misconduct, the tramcar has to bear all the consequences. Had the horse been seriously injured by the bicycle, and the cyclist got off without hurt, we imagine the owner of the horse would have taken action against the cyclist for wedging in on the wrong side, not against Mr. VOLK, who has been running his cars long enough to make every horse in Brighton familiar with their appearance and locomotion.

It is useless, however, to discuss legal subtilties in a newspaper article. Possibly Mr. VOLK may appeal against a judgment which inflicts upon him serious pecuniary damage, though it cannot fix upon him any moral responsibility. If the more sensible portion of the Brighton residents encourage him in that course, no one could blame him for adopting it. We hear some talk of his being supported by local subscriptions, either to defray his costs or to enable him to appeal. Our hope is that he will be safely pulled through his present difficulties, and that even if he has to pay the piper in this case, he will be enabled to carry on the Brighton Electric Railway as if nothing had happened. To Mr. VOLK the electrical world is greatly indebted for the patience and energy he has displayed in working out a problem which, until he succeeded in solving it in a practical way, was regarded almost as an unworkable theory. He has demonstrated the practical and commercial success of electrical tramway undertakings; and whatever shape they may ultimately take, Mr. VOLK will rank as one of their earliest pioneers. In its own interests the electrical world ought to move in this matter. If electric tramcars are to be made the subject of damages in the way Mr. VOLK's appliances have been, the application of electricity to ordinary highways will be rendered impossible. The precedent of the Brighton beach, if applied to the streets of a town, would very soon bring any electric tramway company to ruin. On this account alone, the judgment ought not to go unchallenged, and the more so as Mr. VOLK stands alone, and has fought the battle of electric locomotion for four years past single-handed.

CORRESPONDENCE.

STORAGE BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a frequent reader of the technical papers, and one who, although not an electrician, takes a lively interest in inventions relating to the application of electricity to industrial purposes, perhaps you will permit me to join in the battle of the "elements" now raging in your columns, and more particularly in the columns of your contemporary, between Mr. Sellon on the one hand, and the Union Electric Light and Power Company and its coadjutors on the other.

It appears to me that the advent of a new storage battery which bids fair to eclipse any battery made according to the patents of the Electric Power and Storage Company has the effect of completely depolarising Mr. Sellon, whose rate of discharge, judged by the letters he indites to the papers, is so great that he must inevitably run down very speedily. He was affected in the same way, if my memory serves me right, when he attacked the patents held by the Elwell-Parker Company about a year or so ago, but how that matter ended I know not. Perhaps Mr. Sellon will tell us?

However this may be, I think that, in the present instance, Mr. Sellon should treat your readers seriously, and that the public has a right to demand that this gentleman should endeavour to substantiate his allegations against the Union Company, or withdraw them. As far as I have been able to ascertain, the Union Company have succeeded in producing a battery possessing very remarkable and novel features, and, if the opinions of the experts are to be relied upon, one that is destined to play an important part not only in solving the question of domestic lighting by electricity but also in the manifold other applications for which a battery of this description is especially adapted. The notices of this battery in the press seem to have excited Mr. Sellon, who, although so much interested in this question, has not—as he acknowledges—put himself to the very little inconvenience of learning how the battery is constructed by attending at the offices of the Union Company for the purpose of inspecting the battery, but has clutched at a statement in the press that celluloid is used in connection with the elements, and upon this proceeds to build up a theory that the Union Company is poaching on the mine of wealth contained in that *omnium gatherum* document (the specification of Patent No. 5631, of 1881), because, amongst the numerous other materials therein referred to, *cellulose* is included. He also attacks another of the patents held by the Union Company without, apparently, having the faintest idea whether the Union Battery is made in accordance therewith or not. There are none so blind as those who will not see, and it appears to me that Mr. Sellon's ignorance of the patents held by the Union Company is either due to this cause, or that he is trailing a herring across the path of the public. From information I myself have obtained at the Union Office, I gather that the patents referred to by Mr. Sellon are by no means the most important which the Union Company holds. But, for the sake of argument, supposing this were so, how comes it that Mr. Sellon does not obtain, according to his old patent and with all his experience and perseverance, the remarkable results achieved by the Union Company?

The public, I take it, are not concerned with the question whether Mr. Sellon can claim holes or perforations or corrugations or roughened, indented, irregular, or other surfaces, or "woven shapes" (whatever that may mean), but they are very much concerned with the question as to which battery is the best, and if Mr. Sellon means business, I would suggest that he should do one of two things, viz., either challenge the Union Company to a test or else take a back seat. The public, I believe, is heartily sick of these squabbles, and has had altogether too much of Mr. Sellon's corrugations, and holes, and perforations. Is the march of science to be arrested because this gentleman presents a roughened surface? The vital question is—Has the Union Company made a distinct and important step in advance, and is their battery capable of doing all that is vouched for it by the eminent experts whose opinions bear testimony to it?

I do not think it worth while to comment on the patents held by the Electric Power and Storage Company, but, again, if Mr. Sellon means business, will he produce the opinion of any well known counsel or other person learned in the law of patents to the effect that his patent, which he cites (No. 5631, of 1881), is *on its merits* a valid patent, and without giving attention to any embarrassing questions as to novelty, which questions might arise when his other patents come to be considered? If he can, then let him trot it out. If he cannot, he will do well to give his active material a rest, and modestly accept the inevitable result of his unsupported statements.—Yours, &c., INTERNAL RESISTANCE.

January 26th, 1887.

[We insert the above letter for two purposes; first, to show that differences of opinion are held as to the legal position of Mr. Sellon; secondly, to inform "Internal Resistance" and others that we as well as our contemporary might have filled more space with correspondence on "Secondary Batteries." The reason why we did not insert certain lucubrations was that the same matter was sent elsewhere than to *The Electrician*. We believe that readers of technical papers do not care to turn to the correspondence columns of different papers to read the same letters, and we refuse duplicate insertion of communications whenever we can ascertain they are duplicates, as we imagine we can better fill our space than by the insertion of such duplicate communications. At all times we are glad to receive correspondence and to encourage discussion, but we prefer that readers should consult our columns for that information which is original rather than that which is common to everybody.—ED. *E.*]

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LIFE OF INCANDESCENT LAMPS.

We have been favoured by Mr. G. H. Cottam, the genial representative of the International Electric Co. at Temesvar, Hungary, with a complete table of breakages of lamps during a period of 13 months. So far as we know, a similar record has never been published. The number of hours burnt includes both full and half power. The installation at Temesvar is now working just over 3,646 hours per annum, of these 1,685 hours are with full power, and 1,961 half power. When given as "glass broken," the breakage is malicious.

There are four circuits marked A, B, C, D, having, respectively, 174, 184, 184, and 184 lamps, and on these circuits are, respectively, 119, 118, 132 and 107, or a total of 476 lamps, which have remained from the commencement to the 31st of December, and which have burned over 8,100 hours:—

List of Lamp Breakages which have happened in a total of 768 Lamps between Nov. 1st, 1885, and Dec. 31st, 1886.

Date of Breakage.	No.	Position of Lamp	Cause of Destruction.	Burnt out.	Other causes	No. of hours burnt.
1885.						
Nov. 2	1	10 C 4	Carbon broken	1	...	3623·5
,, 2	2	14 D 6	,, ,, ...	1	...	1821·5
,, 2	3	15 D 3	,, ,, ...	1	...	965·
,, 9	4	4 C 4	,, ,, ...	1	...	3715·5
,, 11	5	22 A 2	,, ,, ...	1	...	3741·5
,, 11	6	3 A 5	,, ,, ...	1	...	3741·5
,, 21	7	8 A 2	,, ,, ...	1	...	3873·5
,, 21	8	16 A 1	,, ,, ...	1	...	3855·
,, 27	9	10 B 5	,, ,, ...	1	...	3951·25
,, 28	10	14 D 1	,, ,, ...	1	...	3965·
Dec. 2	12	6 C 3	Glass ,, ...	...	2	4022·5
,, 6	14	23 A 1	Carbon ,, ...	2	...	4085·75*
,, 8	15	6 C 4	Glass ,, ...	...	1	1896·
,, 8	16	6 C 6	Carbon ,, ...	1	...	4116·75
,, 8	17	23 D 2	,, ,, ...	1	...	4116·75
,, 8	18	2 D 7	,, ,, ...	1	...	4116·75
,, 15	19	6 D 4	Glass ,, ...	...	1	232·50
,, 15	20	4 C 1	Carbon ,, ...	1	...	4210·25
,, 19	21		Glass ,, ...	...	1	4269·25
,, 20	23	3 C 5	,, ,, ...	...	2	1775·75*
,, 20	25	3 C 4	,, ,, ...	...	2	4284·*
,, 22	26	3 C 7	,, ,, ...	...	1	1781·
,, 22	27	16 C 6	,, ,, ...	...	1	4313·50
,, 22	28	9 B 2	Carbon ,, ...	1	...	4313·50
,, 23	29	23 C 6	,, ,, ...	1	...	4328·25
,, 24	30	22 B 3	Glass ,, ...	...	1	4343·
,, 27	31	2 A 5	,, ,, ...	...	1	4387·25
,, 29	32	15 A 5	Carbon ,, ...	1	...	4416·75
,, 29	33	6 A 2	,, ,, ...	1	...	4416·75
,, 30	34	8 C 7	,, ,, ...	1	...	4431·50
,, 30	35	21 D 2	,, ,, ...	1	...	4431·50
1886.						
Jan. 6	36	20 D 8	Glass ,, ...	...	1	4533·
,, 7	37	13 A 2	Carbon ,, ...	1	...	4547·50
,, 9	38	11 D 1	,, ,, ...	1	...	4576·50
,, 10	39	2 A 5	,, ,, ...	1	...	208·
,, 17	40	16 D 3	Glass ,, ...	...	1	3064·75
,, 17	41	19 D 3	,, ,, ...	...	1	4687·25
,, 20	42	23 B 6	Carbon ,, ...	1	...	4728·5
,, 20	43	12 C 8	,, ,, ...	1	...	4728·5
,, 24	44	24 D 2	,, ,, ...	1	...	4781·5
,, 28	45	2 A 4	Glass ,, ...	...	1	4834·5
Feb. 1	46	11 B 2	,, ,, ...	...	1	4887·
,, 1	47	12 B 2	,, ,, ...	...	1	4887·
,, 2	48	9 B 3	Carbon ,, ...	1	...	4899·75
,, 6	49	3 C 9	Glass ,, ...	...	1	4899·75
,, 6	50	9 C 1	Carbon ,, ...	1	...	4950·75
,, 9	51	8 B 2	,, ,, ...	1	...	4989·
,, 10	52	21 B 2	Glass ,, ...	...	1	5001·75
,, 10	53	15 A 3	Carbon ,, ...	1	...	5001·75
,, 10	54	15 B 6	,, ,, ...	1	...	5001·75
,, 16	55	22 A 8	Glass ,, ...	...	1	5075·25
,, 16	56	12 B 6	Carbon ,, ...	1	...	5075·25
,, 16	57	20 D 7	Glass ,, ...	...	1	5075·25
,, 17	58	14 C 4	Carbon ,, ...	1	...	2830·
,, 17	59	8 C 4	,, ,, ...	1	...	5087·5
,, 20	60	16 D 4	,, ,, ...	1	...	1306·
Mar. 2	61	3 A 2	,, ,, ...	1	...	5246·
,, 5	62	3 A 2	,, ,, ...	1	...	44·
,, 5	63	15 D 2	,, ,, ...	1	...	5279·
1886.						
Mar. 6	64	6 B 1	Carbon broken	1	...	4614·25
,, 8	65	8 A 4	,, ,, ...	1	...	5312·
,, 10	66	16 B 2	,, ,, ...	1	...	5333·
,, 10	67	1 D 7	,, ,, ...	1	...	5333·
,, 11	68	12 C 8	Glass ,, ...	...	1	614·
,, 11	70	13 C 4	,, ,, ...	...	2	5343·5
,, 11	71	21 D 5	Carbon ,, ...	1	...	5343·5
,, 14	73	3 C 7	Glass ,, ...	...	2	935·
,, 14	74	3 C 8	,, ,, ...	...	1	5375·
,, 16	75	11 A 5	Carbon ,, ...	1	...	5396·
,, 18	76	20 D 8	,, ,, ...	1	...	902·5
,, 18	77	13 C 3	Glass , ...	...	1	5416·
,, 20	78	16 D 3	,, ,, ...	...	1	765·5
,, 20	79	16 D 4	,, ,, ...	...	1	328·
,, 22	80	16 D 2	,, ,, ...	...	1	5456·
,, 22	82	16 D 3	,, ,, ...	...	2	20·*
,, 23	83	16 D 4	Carbon ,, ...	1	...	30·
,, 23	84	17 D 3	,, ,, ...	1	...	5466·
,, 24	85	23 A 3	Glass ,, ...	...	1	5466·
,, 27	86	6 B 8	Carbon ,, ...	1	...	5504·5
,, 29	87	14 D 8	Glass ,, ...	...	1	5523·5
,, 30	88	2 D 7	Carbon ,, ...	1	...	1431·5
April 2	89	18 B 2	,, ,, ...	1	...	5561·
,, 5	90	16 B 6	,, ,, ...	1	...	5588·75
,, 7	91	7 B 7	,, ,, ...	1	...	5607·25
,, 8	92	7 D 1	,, ,, ...	1	...	5616·5
,, 8	93	14 D 4	,, ,, ...	1	...	5616·5
,, 11	94	19 B 8	,, ,, ...	1	...	5642·75
,, 11	95	11 A 3	,, ,, ...	1	...	5642·75
,, 12	96	2 A 4	Glass ,, ...	...	1	817·
,, 13	97	12 B 5	Carbon ,, ...	1	...	5660·25
,, 14	98	3 D 6	,, ,, ...	1	...	5669·
,, 15	100	13 D 7	Glass ,, ...	...	2	5677·75*
,, 16	101	2 A 4	Carbon , ...	1	...	35·
,, 17	102	13 B 1	Glass ,, ...	...	1	5694·75
,, 20	103	15 B 4	,, ,, ...	...	1	5719·50
,, 20	104	3 D 7	Carbon ,, ...	1	...	5719·50
,, 21	106	5 C 6	Glass ,, ...	...	1	5727·75
,, 21	107	23 C 7	Carbon ,, ...	1	...	5727·75
,, 21	108	9 B 5	,, ,, ...	1	...	5727·75
,, 22	109	14 D 6	,, ,, ...	1	...	5736·
,, 22	110	3 B 2	,, ,, ...	1	...	5736·
,, 23	111	15 C 2	Glass ,, ...	...	1	5744·25
,, 24	112	20 A 6	Carbon ,, ...	1	...	5752·50
,, 25	113	10 C 2	,, ,, ...	1	...	5760·25
,, 29	114	21 C 4	Glass ,, ...	...	1	5791·25
,, 30	115	5 A 3	,, ,, ...	...	1	5799·
,, 30	116	12 A 7	Carbon ,, ...	1	...	5799·
May 2	117	16 D 5	Glass ,, ...	...	1	5814·
,, 3	118	8 C 7	Carbon ,, ...	1	...	1391·
,, 4	119	13 A 2	,, ,, ...	1	...	5829·
,, 7	120	21 C 3	,, ,, ...	1	...	5851·50
,, 9	121	16 A 4	,, ,, ...	1	...	5866·50
,, 10	122	19 B 2	,, ,, ...	1	...	5874·
,, 10	123	5 A 3	,, ,, ...	1	...	5874·
,, 11	124	12 A 1	,, ,, ...	1	...	5881·
,, 11	125	20 D 1	,, ,, ...	1	...	5881·
,, 11	126	20 D 2	,, ,, ...	1	...	5881·
,, 11	127	9 A 6	,, ,, ...	1	...	5881·
,, 12	128	6 A 5	Glass ,, ...	...	1	5888·
,, 12	129	9 A 3	Carbon ,, ...	1	...	5888·
,, 13	130	20 D 5	Glass ,, ...	...	1	5895·
,, 14	131	1 C 3	Carbon ,, ...	1	...	5902·
,, 16	132	22 C 1	,, ,, ...	1	...	5916·
,, 16	133	21 A 8	Glass ,, ...	...	1	5916·
,, 16	134	21 A 1	,, ,, ...	...	1	5916·
,, 16	136	18 A 5	,, ,, ...	...	2	5916·*
,, 16	137	18 A 3	,, ,, ...	...	1	5916·
,, 16	139	18 A 2	,, ,, ...	...	2	5916·*
,, 16	140	19 A 8	,, ,, ...	...	1	5916·
,, 16	142	20 A 1	,, ,, ...	...	2	5916·*
,, 17	143	15 D 7	Carbon ,, ...	1	...	5923·
,, 17	144	15 A 8	,, ,, ...	1	...	5923·
,, 20	145	10 A 1	,, ,, ...	1	...	5944·
,, 22	146	13 A 5	Reserve lamp broken..	...	1	...
,, 24	147	23 B 6	Carbon broken	1	...	1242·5
,, 27	148	16 D 4	Reserve lamp broken..	...	1	...
,, 27	149	22 D 4	Carbon broken	1	...	5981·25
,, 27	150	11 C 2	,, ,, ...	1	...	5981·25
,, 27	151	16 D 3	Glass ,, ...	...	1	5981·25
June 1	153	7 D 8	Carbon ,, ...	2	...	6024·50
,, 6	154	15 D 5	Reserve lamp broken..	...	1	...
,, 11	155	3 D 1	Carbon broken	1	...	6087·
,, 11	156	18 B 5	,, ,, ...	1	...	6087·
,, 11	157	9 D 2	,, ,, ...	1	...	6087·
,, 14	158	7 A 2	,, ,, ...	1	...	6105·75
,, 15	159	13 C 7	Reserve lamp broken..	...	1	...
,, 15	160	11 B 7	Glass broken	...	1	6112·

* Of one only.

* Of one only.

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Date of Breakage.	No.	Position of Lamp.	Cause of Destruction.	Burnt out.	Other causes	No. of hours burnt.
1886.						
June 15	161	20 D 4	Carbon broken	1	...	6112·
,, 16	162	5 D 3	,, ,, ...	1	...	6118·
,, 18	163	18 A 8	Glass ,, ...	...	1	6130·
,, 18	164	10 B	,, ,, ...	...	1	6130·
,, 19	165	4 A 7	,, ,, ...	...	1	6136·
,, 22	167	23 C 5	,, ,, ...	...	2	6154·
,, 24	168	14 B 7	Carbon ,, ...	1	...	6166·
,, 25	169	7 C 8	Glass ,, ...	...	1	6172·
,, 28	170	3 A 2	,, ,, ...	...	1	1351·75
July 1	171	5 D 2	Carbon ,, ...	1	...	6202·
,, 5	172	17 B 1	,, ,, ...	1	...	6232·
,, 12	173	2 B 7	,, ,, ...	1	...	6274·50
,, 13	174	10 D 6	Glass ,, ...	...	1	6280·75
,, 13	175	12 C 7	Reserve Lamp Broken	...	1	—
,, 13	176	12 C 8	,, ,, ,,	...	1	—
,, 13	177	3 C 4	Glass Broken	...	1	6280 75
,, 14	179	14 D 8	,, ,, ...	...	2	6287·
,, 18	180	12 B 2	Reserve lamp broken	...	1	—
,, 19	181	8 C 6	Carbon broken	1	...	6318·25
,, 26	182	15 C 7	Reserve lamp broken	...	1	—
,, 28	183	16 D 2	Carbon broken	1	...	6372·25
Aug. 3	185	5 C 6	Glass ,, ...	...	2	6414·25*
,, 5	187	13 D 7	,, ,, ...	...	2	6428·75
,, 7	188	10 A 7	Carbon ,, ...	1	...	6443·25
,, 10	189	13 D 6	,, ,, ...	1	...	6465 5
,, 13	190	12 B 4	,, ,, ...	1	...	6488·
,, 13	191	12 C 4	,, ,, ...	1	...	6488·
,, 13	193	14 C 6	Glass ,, ...	...	2	6488·
,, 13	194	11 A 8	Reserve lamp broken	...	1	—
,, 13	195	1 A 2	Carbon broken	1	...	6488·
,, 13	196	3 B 5	,, ,, ...	1	...	6488·
,, 16	197	9 B 2	Reserve lamp broken	...	1	—
,, 20	198	12 C 6	,, ,, ...	...	1	—
,, 22	199	17 B 1	Carbon broken	1	...	374·75
,, 22	200	23 B 6	,, ,, ...	1	...	727·25
,, 26	201	11 D 5	,, ,, ...	1	...	6594 75
,, 26	202	2 B 4	,, ,, ...	1	...	6594·75
,, 26	203	23 A 2	Reserve lamp broken	...	1	—
,, 26	204	6 D 2	,, ,, ,,	...	1	—
,, 26	205	10 D 3	Carbon broken	1	...	6594·75
,, 26	206	10 D 2	,, ,, ...	1	...	6594·75
,, 26	207	9 D 7	,, ,, ...	1	...	6594 75
,, 26	208	10 D 4	,, ,, ...	1	...	6594·75
,, 26	209	10 D 6	,, ,, ...	1	...	327·75
,, 26	210	8 D 2	,, ,, ...	1	...	6594·75
,, 26	211	10 D 8	,, ,, ...	1	...	6594 75
,, 26	212	10 D 7	,, ,, ...	1	...	6594·75
,, 26	213	11 D 3	,, ,, ...	1	...	6594·75
,, 26	214	4 D 5	,, ,, ...	1	...	6594·75
,, 26	215	11 D 2	,, ,, ...	1	...	3986 25
,, 26	216	11 D 1	,, ,, ...	1	...	2020 75
,, 26	217	11 D 8	,, ,, ...	1	..	6594·75
,, 26	218	12 D 2	,, ,, ...	1	...	6594·75
,, 26	219	10 D 1	,, ,, ...	1	...	6594 75
,, 26	220	9 D 1	,, ,, ...	1	...	6594·75
,, 26	221	7 D 8	,, ,, ...	1	...	584·
,, 30	222	10 D 5	,, ,, ...	1	...	6594·75
Sept. 6	223	11 B 2	Reserve lamp broken	...	1	—
,, 6	224	9 B 3	,, ,, ,,	...	1	—
,, 9	225	18 C 1	Carbon broken	1	...	6701·75
,, 9	226	14 C 7	,, ,, ...	1	...	4099·50
,, 10	227	23 D 8	Reserve lamp broken	...	1	—
,, 12	228	13 B 1	,, ,, ,,	...	1	—
,, 14	229	14 A 8	Carbon broken	1	...	4103·5
,, 14	238	11 A 3	Glass ,, ...	...	1	1140·5
,, 16	231	22 B 6	,, ,, ...	...	1	6777 75
,, 17	232	11 D 6	,, ,, ...	...	1	3977·
,, 17	233	9 B 5	Carbon ,, ...	1	...	1084·5
,, 18	234	19 C 5	Reserve lamp broken	...	1	—
,, 18	235	12 D 1	Carbon ,, ...	1	...	6797 75
,, 18	236	16 D 1	Glass ,, ...	...	1	4135·25
,, 19	237	13 C 6	Reserve lamp broken	...	1	—
,, 22	238	6 C 2	Glass ,, ...	...	1	6837·75
,, 23	239	6 C 4	,, ,, ...	...	1	2627·50
,, 23	240	14 C 6	Carbon ,, ...	1	...	373·5
,, 29	240	18 C 6	,, ,, ...	1	...	6910·25
Oct. 1	241	15 D 3	,, ,, ...	1	...	3300·50
,, 2	242	19 D 8	,, ,, ...	1	...	6942·25
,, 3	243	12 B 3	Glass ,, ...	...	1	6953·
,, 3	245	17 C 7	,, ,, ...	...	2	6953·
,, 14	246	21 A 3	Carbon ,, ...	1	...	7074·25
,, 15	247	11 B 8	,, ,, ...	1	...	3913·5
,, 15	248	6 A 2	,, ,, ...	1	...	2489·
,, 16	249	19 D 5	,, ,, ...	1	...	7096 75
,, 16	250	7 A 8	,, ,, ...	1	...	7096·75
,, 17	251	6 A 3	Glass ,, ...	...	1	7108 50
,, 17	252	3 A 3	Carbon ,, ...	1	...	7108·50
,, 18	253	9 B 4	,, ,, ...	1	...	7120·25

* Of one only.

Date of Breakage.	No.	Position of Lamp.	Cause of Destruction.	Burnt out.	Other causes	No. of hours burnt.
1886.						
Oct. 21	255	20 C 1	Carbon broken	1	...	7155·50
,, 21	256	20 C 2	Reserve lamp broken ..	...	1	..
,, 26	257	6 D 4	Carbon broken	1	...	7235·25
,, 26	258	18 A 3	,, ,, ...	1	..	1652·75
,, 27	259	11 C 3	Reserve lamp broken ..	...	1	...
,, 27	260	17 A 7	Glass broken	...	1	7247·50
,, 28	261	18 D 7	Carbon ,, ...	1	...	4670·50
,, 28	262	17 A 7	,, ,, ...	1	...	4·
,, 29	263	11 D 1	,, ,, ...	1	...	668·50
Nov. 1	264	21 B 6	,, ,, ...	1	...	7292·
,, 2	265	22 B 2	,, ,, ...	1	...	7304·25
,, 2	266	16 B 7	,, ,, ...	1	...	7304·25
,, 3	267	14 A 5	,, ,, ...	1	...	7316·
,, 3	268	20 A 8	,, ,, ...	1	...	7316·
,, 3	269	21 D 5	Reserve lamp broken..	...	1	...
,, 4	170	4 D 7	,, ,,	...	1	...
,, 5	171	17 D 7	,, ,,	...	1	...
,, 5	172	13 C 7	Carbon broken	1	...	1253 50
,, 7	273	8 A 2	,, , ...	1	...	3659 50
,, 14	274	13 A 3	,, ,, ...	1	...	5141·25
,, 14	275	9 C 4	Glass ,, ...	...	1	7455·25
,, 15	276	16 D 7	Carbon ,, ...	1	...	7468·50
,, 16	277	18 A 5	, ,, ...	1	...	1583 75
,, 17	278	5 A 3	,, ,, ...	1	...	1639·
,, 18	279	16 A 5	Reserve lamp broken ..	...	1	...
,, 18	280	12 A 1	Carbon broken	1	...	1645·25
,, 19	281	20 B 2	,, ,, ...	1	...	7521·
,, 24	282	4 C 8	,, ,, ...	1	...	7588 75
,, 28	283	23 D 2	,, ,, ...	1	...	3572 25
,, 29	284	21 B 7	,, ,, ...	1	...	7656 25
Dec. 2	285	7 A 2	,, ,, ...	1	...	1604·
,, 3	286	23 A 1	,, ,, ...	1	...	3656·75
,, 4	287	14 B 7	,, ,, ...	1	...	1575·25
,, 5	288	17 B 3	,, ,, ...	1	...	7739·75
,, 6	289	19 B 5	,, ,, ...	1	...	7753 75
,, 13	290	15 A 7	... ...	...	...	...
,, 16	291	19 C 3	... ...	1	...	7893·75
,, 16	292	19 D 7	Reserve lamp broken ..	...	1	...
,, 17	293	6 D 7	Carbon ,, ...	1	...	7907·75
,, 17	294	2 A 7	,, ,, ...	1	...	7907·75
,, 17	295	15 B 5	,, ,, ...	1	...	7907·75
,, 18	296	5 B 3	,, ,, ...	1	...	7921·75
,, 18	297	11 B 5	,, ,, ...	1	...	4618·50
,, 20	298	2 A 7	,, ,, ...	1	...	7949 75
,, 22	299	12 B 1	,, ,, ...	1	...	7977·75
,, 22	300	13 D 5	Glass broken	...	1	7977·75
,, 22	301	13 D 6	,, ,, ...	...	1	1506·50
,, 22	302	23 D 3	Carbon ,, ...	1	...	7977·75
,, 26	393	15 D 7	Reserve lamp broken ..	...	1	...
,, 26	304	16 D 6	,, ,,	...	1	...
,, 26	305	17 D 7	Carbon broken	1	...	8033·75
,, 26	306	20 A 8	,, ,, ...	1	...	8033 75
,, 31	307	3 C 8	,, ,, ...	1	...	2693·25
,, 31	308	22 D 7	,, ,, ...	1	...	8103 75

RECENT PRACTICE IN THE EDISON SYSTEM OF DISTRIBUTION.

In our issue of the 17th ult. we gave a diagram showing the fluctuations in the demand for current from the central lighting station at Boston, which supplies 10,000 Edison 16 candle-power lamps. This company was only formed in the early part of last year, so that the details which we are now able to give as to the construction of the mains and conduits afford an illustration of the most recent practice in the system of parallel distribution direct from the dynamo. The network consists of a three wire system, combined with four sub-central points, each connected with the dynamo room by a set of feeders, of which the number in use is varied in accordance with the requirements of the moment. Although this latter feature has been brought into use in this country it is obviously a mistake, as the same effect might be produced with less heating of the cables themselves, and greater nicety of adjustment, by the mere insertion of a graduated resistance in the machine room.

Fig. 1 is a plan of the + feeders and mains. It will be seen that by means of cross-connections every lamp upon the installation can be reached through any one of the sub-centres.

The feeders consist of continuous lengths of insulated cable, and are laid in wooden boxes (which are probably creosoted), and filled with a special insulating compound, poured in hot.

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The mains from which the consumers are directly supplied consist of iron tubes, each 20ft. in length, containing three separately insulated copper leads. The sizes of the tube and leads vary, of course, with the requirements of the district, but a 2½in. tube takes three ⅝in. leads. The tubes are sent out

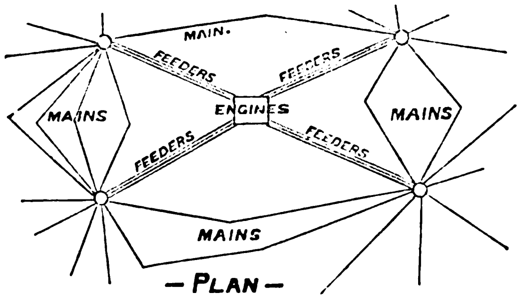

Fig. 1.

ready for use, the insulating material being previously run in around the leads. At the end of every 20ft. length is placed a junction box, wherein the ends of the leads may be connected by a short length of cable, or from which leads may at any time be taken off to the consumer's premises. The way in which the connections are made will be clear from the following figures and description. (We copy the figures from a recent number of the *New York Sanitary Engineer*.)

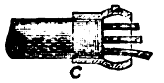

Fig. 2.

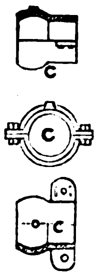

Fig. 3.

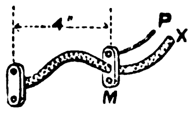

Fig. 4.

On the end of each iron tube is first bolted a coupling, C (of which three sections are shown in Fig. 2). Each main wire is then soldered to a yoke, D (Fig. 3), which is already connected to a short length of cable, the other end of the latter being joined to a similar yoke, which is then soldered to the corresponding lead of the succeeding tube. If any consumers are to be connected with this box their wires are soldered to the yoke D. In Fig. 3 M is the main and P a consumer's wire.

The distributing boxes (Fig. 4) are of cast iron, made in two sections, bolted together with flanges; a specially shaped box is used for corners. The lower half is first placed in position and bolted to the tubes by means of the collar C. The upper half is then laid on, the consumers' wires pass out through an opening in the top, the whole is bolted together, and insulating composition run in.

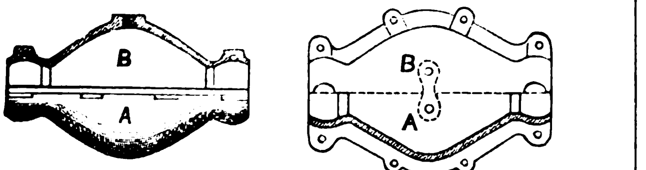

Fig. 5.

Separate "pressure wires" are run back from each sub-centre so as to enable the potential to be kept right. Edison meters of the usual type are in use. The company anticipate an early extension of their plant to a total capacity of 40,000 lights.

PRIMARY BATTERIES.

BY SIDNEY F. WALKER.

(Concluded from page 244.)

To get over these difficulties it is usual to amalgamate the zinc, more especially where it is used in acid; but where the battery does much work, although apparently the mercury has penetrated right into the mass of the zinc, after a time the old state of things returns, and you have to re-amalgamate your zinc, in doing which you often break it if it happens to be a plate or hollow cylinder, as the process of amalgamation renders it very brittle. So long as it remained undisturbed in the battery it would probably have held together, but immediately you begin to handle it to re-amalgamate you will be very fortunate indeed if you do not break it if the plate is at all thin. Two new departures have been made in this matter with a view of getting over this difficulty, though one, the "Upward," is perhaps hardly correctly so described. In this—the Upward—the zinc stands in a solution of its own chlorine, and as the salts it forms are apparently soluble in the zinc chloride the condition above named is fulfilled. It is stated that the zinc used is only scrap zinc cast, no amalgamation being required. We had the same thing in the early days of the Leclanché cell, but experience has shown that it is wiser to amalgamate, as the zincs last better. The other plan, which is due to Mr. Maquay—and proposes to get over the difficulty of the exhaustion of the mercury in another way—is to form the generating plate of an alloy of zinc with mercury and a small proportion of other metals, so that the plate when finished contains sufficient mercury in combination with the zinc to last as long as the plate will hold together. The plate thus formed does not require re-amalgamating. It may also be mentioned in connection with the Upward that if the zincs are cast from scrap battery zinc, these may contain sufficient mercury without further process. But when we have got over all these difficulties, our troubles with regard to the formation of the salts in working are not at an end. The solvent powers of any solution for any salt formed are always more or less limited, so that after the battery has been working a certain time, unless fresh solution be provided, local action will commence, and our working current will go down.

It is necessary, therefore, if our battery is to furnish a constant current, that the quantity of liquid in which the zinc is immersed should be in proportion to the total amount of work to be done; or, in other words, to the total quantity of salts that will be formed during the run. Next, constancy demands that the resistance offered by the porous division, if there is one, shall not vary. It must be remembered that the porous material is not in itself a conductor, and that the current passes, for practical purposes, only by way of the conducting liquid, which percolates through it. Anything, therefore, which tends to fill its pores with a high resisting medium, or by causing the expansion or contraction of the cell itself, to close its pores, increases its resistance, and may virtually break the current. It is important, therefore, to choose such a porous division, and such conducting liquids that the pores shall not fill up during work in either manner described.

In the early days of the Leclanché battery it was no uncommon thing to find a filled porous cell which apparently looked as good as new, and yet would not only give no current itself but introduced such a high resistance into the circuit as to stop the passage of the current from the other cells owing to its pores having become filled up. This question of the porous division is, perhaps, as awkward to deal with as any part of the subject, owing principally to difficulties of manufacture. It is apparently impossible for makers of porous cells to construct one which in use shall neither become hard nor scale—that is, whose pores shall not fill up—nor its substance break away under the action of salts, which are formed in the working of some batteries. The matter appears to be of more importance in the case of such cells as the Lechanché and the Daniell cells than in that of the acid batteries. In the latter, in fact, provided a certain porosity is obtained at the start, a certain hardness is no disadvantage. In the mercury-bichromate battery used for telegraphy, for instance, we choose moderately hard cells, and find they answer well, where, with the Leclanché, they would not. For the latter, I have always preferred a soft cell, one not too soft, but that tends to break rather than to fill up.

The battery which can dispense with porous divisions has an enormous advantage, but up to the present no practical battery, except that of M. Schanschieff, has been proposed for heavy work in which no porous cell is used; for the reason, that no other liquid except that which he uses has been discovered that will furnish the required energy by the combination of one or more of its constituents with the generating plate, and at the same time use up the other components in the manner required for constancy of current. In the newly introduced "Upward" battery, however, it is difficult to see what office the porous division fills that could not be filled equally as well by means of the carbon cell itself without any separator whatever. Next, in order that the current delivered may be constant, the supply of oxidising or depolarising substance must be sufficient for the time the battery is at work, and must be available as required for the whole time. If the salt from which the depolariser is taken refuses to neutralise the hydrogen gas and other matters as fast as they are formed, your current immediately falls, on account of the resistance and opposing E.M.F. introduced. This is one great weakness of the Leclanché cell. If you work the cell too hard, the gas is not properly neutralised, and down goes your current. A simple remedy for this, for most purposes for which the Leclanché is used, is to adopt larger cells. The cost, for instance, of a No. 1 Leclanché is not 50 per cent. greater than that of a No. 2, yet the No. 1 filled

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porous will last out three of the No. 2 for the same work, and will stand to its work under conditions that would break the latter down. One great fault, of many otherwise good oxidising agents is that they will act very powerfully at first and then gradually exhaust their powers. Again, it is a condition of constancy that in the depolarising action there should be no formation of salts that go to vary the resistance of the cell. It is manifest that, starting with certain liquids or other substances offering certain resistance, if the result of the chemical action attendant upon the neutralising of the hydrogen gas be the formation of another liquid whose specific resistance is higher than that of the primary liquid, the resistance of your cell must go up and your current go down, and *vice versâ*, unless the action of another part of the battery tends to neutralise this; that is to sap, supposing two or more liquids to be concerned in the working of the battery, if the resistance of one is raised by the chemical reactions, that of the other should be lowered to the same extent, if constancy is to be preserved. If the action of one liquid or one component gives us an increase of, say, $\frac{1}{10}$th ohm, that of another should give us a decrease to the same extent. The same remark applies to salts forming on either plate. If, though these be not themselves soluble in the liquid in which they are immersed, they immediately form new combinations with other salts in solution and the newly formed salts are soluble, the resistance at the surface of the plates will remain constant. It is also necessary that if metals are deposited at the negative plate, they should be deposited in such a manner as neither to increase resistance nor develop E.M.F.'s opposing the primary. Thus in the Daniell battery we have copper which is displaced from its solution of cupric sulphate deposited upon a copper plate. If it were deposited upon a carbon plate we should have another cell formed between the carbon, copper, and the liquid—a very weak one, possibly, but a nuisance nevertheless. Further, it is necessary that the liquid used to combine with the generating plate and that used for depolarising, if two are used, should mix as little as possible, and that their mixing should not tend to either increase or decrease the resistance of the cell, to develop counter E.M.F.'s, nor to rob either the liquid in which the zinc is immersed of its solvent properties, or that in which the negative plate stands of its depolarising properties, nor by mixing to form new salts which have a higher specific resistance.

Another of the causes of failure of the Leclanché cell for continued work and for really constant currents is the formation of secondary salts which are not so readily soluble in the sal-ammoniac solution, and which tend to crystallise out within the porous cell, forming round the oxide of manganese and carbon, and within the pores of the cell itself, thereby introducing resistance and E.M.F.'s at variance with the primary. In the Daniell battery, again, the copper solution usually works through to the zinc, forming a deposit of copper there and giving rise to local action, and frequently also metallic copper is found in the porous division. Many plans have been suggested to avoid this, the best being the gravity arrangement, where no porous cell is used, advantage being taken of the different specific gravities of the solutions to separate them. But even here they mix after a time, and the arrangement necessitates such a distance between the copper and zinc plates that the resistance of the conducting liquids becomes very high, rendering the battery, in fact, useless for any work except such as requires only weak currents. It need hardly be pointed out how important it is for constancy to have pure chemicals. Most commercial salts, unless specially prepared, contain impurities, and it is quite possible that the working of a really first-rate battery may be quite upset from this cause alone. The impurities will most certainly form combinations of their own which will almost as certainly work against all that has been said as to the requirments for constancy. There is no more fruitful source of trouble with the Leclanché than impure sal-ammoniac. It breaks your porous cells, and often reduces the life of your complete inside cell from half to three-quarters of its proper duration. It is, of course, very important that the resistance of your battery plates should not vary appreciably. The resistance of the zinc plate or rod will, of course, become greater as it is consumed, but the rise from this cause is usually only very small, the resistance of the mass of the zinc plate forming a small proportion of the total resistance of the cell itself. The plates used as negatives are also usually not readily attacked, yet that of carbon rises from the crystallisation of salts within its pores, or by the action of strong chromic acid. The next most important feature in connection with successful primary batteries is that the working cost should be small. This is made up of several factors:—1. The materials actually consumed in generating the current. 2. The attendance required to keep things in order. 3. The wear and tear upon different parts of the battery which are not actually engaged in the generation of the current, such as carbon or platinum plates, porous cells, jars, clamps, &c.

The cost of the materials consumed for the work done is, of course, the most important charge when the actual work done in the battery, as in electric lighting, is large. With telegraph or telephone batteries the materials consumed usually bear a very small proportion to the total cost of maintenance; still, even in these cases, where thousands or even millions of batteries are used, a saving of materials is a consideration. One penny per cell upon a million cells would amount to more than £4,000, which would pay 10 per cent. upon a capital of £40,000. With large currents cheapness of materials is a *sine quâ non*. It would be useless, for instance, to design a battery, however perfect in every other respect, in which salts of the rare metals were used; and here it may be remarked that cheapness of materials includes their being readily obtainable and easy of transportation. Any system of maintenance of electric light batteries would be killed if the materials used were such that the railway companies imposed a prohibitive tariff upon their carriage. On this point, too, it is well to remember that, up to a certain point, the cost of materials lessens with increased demand, with the one exception, of course, of the case where Nature is the manufacturer, and has only seen fit to make or deposit a certain quantity, which, again, is held in certain hands who will take full advantage of it. On the other hand, it would be false economy to use even the cheapest materials unless a proportionate return was obtained. Under the head, also, of consumption of materials, we have to include all waste, such, for instance, as ends of zinc plates that cannot be used, allowing of course for their casting up value, portions of solutions that cannot be completely combined, portions lost from mixing, and above all any consumption of generating plate or solutions which goes on when the battery is supposed to be at rest.

Next in importance in the total cost, and, in fact, the most important item in telephone and telegraph work, is that of attendance. A battery may have all the qualities we have claimed as necessary in a primary battery, yet if its construction be such as to entail a high charge for attendance, it cannot be successful commercially. And in order that the cost of attendance may be low, the construction of the battery must be simple. If this is so, if the attendance required resolves itself into a few simple operations, such as adding sal-ammoniac, water, cleaning connections, and an occasional wash out, as in the Leclanché, a very much inferior, and therefore a very much cheaper, class of labour may be employed than in a battery, or, in fact, any apparatus, where there are any adjustments to be made, any delicate parts to be cleaned, or any parts that by getting out of adjustment may upset the working of the battery. Uneducated men, and occasionally trustworthy lads, may be employed, and it is found in practice that not only is their rate of wages low, but there is an actual saving in point of time, as they in no long time become very expert and quick at doing these little things when they are done so often, and not only quick but exceedingly trustworthy. Whereever you have complications, however desirable the result obtained may be, you must for your own safety, if you are responsible in any way, have men at least in the position and drawing the wages of skilled mechanics, and your increased expense does not end there. Longer time is almost sure to be taken over the work, if it is done properly. The skilled labourer, as a rule, has a strong feeling of *esprit de corps*, if one may use the term; he will not, if he can possibly avoid it, allow a chance of his work going wrong after he has left it. I am, of course, referring here to the good workman, not to the man who "boozes" and scamps his work. And this very pride will lead him, in making sure that he leaves *everything* right, to take more time. The number of the solutions or components used in the battery has of course an important bearing on the question of attendance. A battery with just a couple of plates standing together in one liquid, if it works well, would be far preferable to one in which two liquids are employed, more particularly if one or both of the latter are compounds of several ingredients.

Again, a battery which has no porous division, or in which the whole of the negative element, plate, and oxidising material, can be changed together, has a very great advantage over one in which the porous division separates two liquids, which possibly require separate treatment. This is one of the great advantages of the Leclanché cell, and it is not too much to say that the rapid advance which has been made in the use of telegraphs, signals, telephones, and electric bells for different purposes, is due very largely to the introduction of that cell, and that if it is ever superseded it can only be by a cell which combines all its advantages of simplicity, cleanliness, &c., with others which it does not possess. The other item in the cost of maintenance is wear and tear of the parts which are not concerned in actively transforming chemical into electrical energy, such as porous cells, glass or other containing jars, carbon, platinum or copper plates, clamps, &c. In the opinion of the writer, earthenware jars are much to be preferred to glass for most work, as they are less liable to be broken, and though they are heavier they can now be obtained from several well-known firms equally durable as glass against the action of the strongest acids. Glass jars have an awkward trick of breaking a corner out, and

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emptying themselves of their liquid. They have, however, the advantage that by properly arranging the cells one can see inside, the colour of solutions, &c., which, especially in the case of bichromate batteries, is an important matter. Of the other materials, ebonite, insulite, wood cased with marine glue, the writer has not much experience, and their cost is usually prohibitive, while some of them have a tendency to crack. Their weight and compactness are, however, greatly in their favour, and if a substance were produced equally as cheap as glass or earthenware, with the properties of vulcanite or insulite, and able to resist the strongest acids, it would probably carry the market. While jars are only a possible source of waste, porous cells must be reckoned on, so far as manufacturing has gone at present, as a regular item of expenditure in any system of primary battery maintenance, except, of course, those few in which no porous division is used. As has been already pointed out, porous cells, from the action of the salts which are constantly forming, either disintegrate or fill up, so that in either case they have to be replaced, and the difference between porous of good manufacture and of bad, between quick action and slow, is merely one of time. Still, where a large number of batteries are used, the cost of porous may be a considerable item, and it may therefore be laid down as another requirement of a good primary battery that its action upon the porous of good manufacture shall be as slow as possible. Carbon plates also become useless after a time from almost the same causes as porous cells. They are porous, and their pores become filled with the salts which are formed in the working of the battery, whereby their resistance is raised, and they may even break. They become brittle, as do also copper and platinum plates, and break in handling. Clamps or wires or other connections may also be another source of expense unless properly protected. A careless attendant spills water or acid over them, or handles them with fingers impregnated with acid; or salts are allowed to creep up the plates and form on the clamp; or, lastly, fumes may arise, deposit on the clamp, and attack it.

Again, it may be laid down that, other things being equal, that battery is best in which there is less tendency for this to happen, as it not only wastes clamps, but necessitates labour in cleaning. The creeping of the salts up a carbon plate may be prevented by properly paraffining the top of the plate, and the clamps in the same way. A thin layer of paraffin apparently protects the clamp, and does not offer much resistance.

It only now remains to give a few hints as to testing. How is an outsider to know if a battery will fulfil the conditions laid down? The accurate determination of the E.M.F. and internal resistance must be made in a laboratory by one of the methods given in the text books, but for practical applications a sufficiently correct idea of the former may be obtained by the aid of a high-resistance voltmeter reading to $\frac{1}{10}$ths of a volt. A low-resistance low-reading voltmeter will not give correct results, as its own measuring current makes a charge upon the initial E.M.F., and therefore the reading is below the correct one. To obtain the internal resistance of batteries used for electric lighting, &c., sufficiently near for practical purposes—having obtained the E.M.F. on open circuit with a voltmeter whose resistance is sufficiently high not to affect the result—allow a current of known strength to pass, say 1 ampere, or any convenient number, and again measure the E.M.F. at the terminals of the cell or battery; the fall of E.M.F. divided by the current will give the resistance $R = \frac{E}{C}$. For constancy, with batteries furnishing large currents, no method is perhaps better than allowing a current of known strength to pass through a resistance and an ammeter graduated to show small variations of current strength. The resistance may be a small incandescent lamp, or a length of iron, German silver or copper wire; but it must be remembered that the resistance of all of these materials varies from the heating effect due to the passage of the current through them, and in estimating the constancy of the current furnished by the battery this variation in the resistance opposed to it must be taken into account.

For telephone and telegraph batteries a very good approximate test can be made of their E.M.F. and internal resistance by means of an ordinary detector wound with a thick and thin wire circuit, comparison being made with a cell whose E.M.F. and resistance are known. For constancy a favourite test is to put a cell to ring a trembler bell. This is a very good plan, but is apt to be a nuisance to those who are in the building when the test is going on. A test the writer has applied with success is to connect up several cells in circuit with the thin wire high resistance circuit of a detector galvanometer, so as to allow a very small current to be constantly passing, and test each cell on the low-resistance circuit day by day. This is a more severe test than actual work, except in those cases where batteries work all closed circuits; but it is a thoroughly reliable one. No cell which stands that test will break down in practice, and it is obvious that it is a fair one to all the cells which are under test, as they are all subject to exactly the same conditions. It enables, too, a comparison to be made of a number of cells together, which would hardly be convenient with each cell ringing a trembler bell separately. The writer has had as many as two dozen cells of different kinds under comparative test of this kind for six months together, each cell being tested each morning with high and low-resistance circuits of a detector galvanometer. As a cell worked completely out, it was taken out, allowed to recover, if able to do so, and replaced till quite exhausted.

The writer hopes that the above practical hints may be of service to the readers of *The Electrician.*

THE ANGLO-AMERICAN TELEGRAPH COMPANY.

The following report has been received too late for insertion in its proper position.

Report of the Directors to be presented to the ordinary general half-yearly meeting of the proprietors, to be held at Winchester House, 50, Old Broad-street, E.C., on Friday, the 4th February, at 2 o'clock p.m.:—

The total receipts from 1st July to 31st December, 1886, including a balance of £2,423. 19s. 2d. brought forward from the last account, amount to £89,808 17s. The traffic receipts show a decrease as compared with the corresponding period of last year of £54,683, consequent upon competition and a reduced tariff. The total expenses of the half-year, including repair of cables, &c., as shown by the revenue account, amount to £54,461. 13s. 10d. The balance of revenue, after deducting working expenses, amounts to £35,347. 3s. 2d., which the directors, under the powers conferred upon them by the Articles of Association, have placed to the credit of the renewal fund, bringing that fund up to a total of £966,906. 3s. 6d. The company's repairing ss. "Minia" has been engaged during the past half-year in the repair of the Prince Edward Island, Duxbury, Brest, and Valentia 1873 and 1874 cables; also of the Direct United States Cable Company's short section between Torbay and Rye-Beach, the remuneration for which will be found in the revenue account. The Company's system of cables and land wires is in good order, with the exception of the Brest–St. Pierre and St. Pierre–Duxbury cables, the former of which was again broken in deep water at a distance of 600 miles from St. Pierre on the 9th of November, and the latter in shallow water at a distance of 226 miles from Duxbury, on the 9th of January. The rupture of the Brest–St. Pierre cable is believed to be in a depth of about 2,750 fathoms, and it is feared that its repair will be a long and costly operation. The "Minia" is on her way to the locality of the break, and has been ordered to take a series of soundings in the immediate neghbourhood, which will be done as soon as the weather permits. It is not proposed, however, to commence operations for the repair of the cable before June next. The Commercial Cable Company (Mackay-Bennett cables) has succeeded during the past half-year in obtaining control of the direction of the Paris and New York Telegraph Company, one of the parties to the joint purse agreements. At a special general meeting of that company, held in Paris on the 6th October last, the majority of the old Board of Directors were replaced by new men, the object of the change being to break up the alliance with the English and Western Union Companies. On the 31st December last, the new managing director of the French company gave formal notice to the other companies that the joint purse agreements would thenceforth be at an end so far as regarded his company, the reason assigned being a letter from M. Granet, the French Minister of Posts and Telegraphs, that the French Company were, with respect to those agreements, not acting in accordance with the terms of their concession. This decision of the French Minister is directly opposed to that of his predecessor, M. Cochery, to whom the principal agreement was duly submitted in 1881 before it came into operation. The Directors are advised that the action of the French Company is illegal, and that in the event of continued refusal to carry out their engagements, heavy damages can be obtained by the other parties to the agreements. The tariff at sixpence per word has been in operation during the whole of the past half year, and has resulted in a still further increase of traffic carried by the Associated Companies. For the eight months since the 5th of May, it has amounted to 129 per cent. more than for the corresponding period in 1885. During the last three months of the year, however, the increase was 122, 145, and 151 per cent. respectively, as compared with the same months last year, which shows that the large increase at first noticed is progressing satisfactorily, and encourages the Directors to hope that if the improvement of trade between Europe and America should continue, the permanent establishment of low rates may become an accomplished fact. A new cable company has been launched during the past half-year. The prospectus of the "International Cable Company," for cables between Europe and North America, *viâ* the Azores, was issued in the month of November, and notwithstanding the depressed condition of all the existing cable companies to America, and the fact that there are already 10 cables across the Atlantic, some of the shares of the new company were allotted, although the stocks of the old companies could have been bought at from 60 to 75 per cent. discount. The foregoing facts point to the necessity of continued efforts on the part of the associated cable companies to maintain low rates. It is probable that had high rates been in force when the prospectus of the new company was issued the whole of the capital offered would have been subscribed. In accordance with the Articles of Association, two Directors of the Company—the Marquis of Tweeddale and Cyrus W. Field, Esq.—retire at this meeting, and being eligible offer themselves for re-election. Mr. Joshua Dean and Mr. Francis Glass, the auditors, also retire and offer themselves for re-election.

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PHYSICAL SOCIETY.—January 22.

Prof. McLeod, Vice-President, in the chair.

Dr. F. Wormack was elected a member of the Society. The following papers were then read: *The Permanent and Temporary Effects on some of the Physical Properties of Iron produced by Raising the Temperature to 100°C.*, by Mr. Herbert Tomlinson, B.A. The paper is divided into three sections, (1) Internal Friction of Iron, (2) the Longitudinal and Torsional Elasticities of Iron, and (3) the Velocity of Sound in Iron. In his experiments on the internal friction of metals the author uses a vertically suspended wire rigidly clamped at its upper extremity, and having its lower end secured to a horizontal bar of metal, attached to which are two cylinders of equal mass and dimensions, placed at equal distances from the wire. When the system is set in torsional oscillation the amplitude gradually diminishes, due to the internal friction of the metal and the friction of the air. The combined effect is measured by the logarithmic decrement of the oscillations, and the air effect eliminated by Prof. Stokes' formula and the author's experimental determination of the viscosity of air. When the deformations are sufficiently small the experiments prove that the logarithmic decrement of arc is independent of the amplitude and period of vibration. These results are only true when the wire has been allowed to rest a considerable time after any change has been made in the arrangement, and when there have been a large number of oscillations executed previous to the actual testing. Reference is made to some experiments by Prof. G. Wiedemann, which show that when a wire is subjected to torsional stress it does not recover itself when the stress is gradually reduced to zero, but remains permanently twisted through a small angle (say θ). By reversing the twisting couple there is a permanent set on the other side of the initial position. If the operations be repeated θ diminishes and attains a minimum. The period during which this diminution takes place is called the "accommodation period." When a wire is in torsional vibration the position of equilibrium is continually shifting to and fro, through twice the above minimum angle, and Wiedemann considers the loss of energy due to this shifting. The author's experiments verify Wiedemann's results, and also show that time and temperature have great effect on the internal friction. By repeatedly heating to 100°C. and slowly cooling an annealed iron wire for six days the logarithmic decrement due to internal friction was reduced to about $\frac{1}{8}$th its original amount, at the same temperature, and when the wire was maintained at 98°C. the decrement was reduced to $\frac{1}{30}$th. The author considers the permanent diminution produced by heating and cooling to be mainly due to the slow shifting backwards and forwards of the molecules, induced by that process. In the second part of the paper it is shown that the effects of change of temperature on the longitudinal and torsional elasticities of iron and steel are not nearly so great as that produced on the internal friction. Thus by heating annealed iron wire its longitudinal and torsional elasticies are slightly decreased, but on cooling there is a permanent increase in both. Time is also an important element, for a long rest after cooling still further increases both elasticities. From the above results it is evident that the velocity of sound in iron and steel must *diminish* with rise of temperature. This was experimentally proved before the meeting. Attention was particularly directed to this fact because most of the best text-books make the opposite and erroneous statement. Remarks were made by Mr. C. V. Boys, and the Chairman mentioned a new form of clock, whose action depends on torsional elasticity of a steel wire.

On Some New Measuring Instruments Used in Testing Materials, by Prof. W. C. Unwin, F.R.S. In most measuring instruments previously used it has been considered sufficient to make the measurement of elongation from one side of the bar, but this, the professor showed, was liable to serious error, owing to the fact that test bars are not always perfectly straight, and to the possibility of originally straight bars being bent by improper fixing in the testing machine. In such cases the modulus of elasticity, calculated from the apparent elongations, are subject to considerable error. In endeavouring to overcome these difficulties the author has devised several new forms of measuring apparatus, which are attached to two sides of the bar by steel points and the mean elongation of the two sides determined. The first apparatus described consists essentially of sliding callipers read by microscopes to $\frac{1}{10000}$th of an inch. Another form has two clamps provided with sensitive levels. Each is attached to the bar by two steel points, the line joining which is perpendicular to the direction of the stress, and the clamp can rotate in a vertical plane about this line as an axis. The lower clamp is levelled by a screw pressing against the surface of the bar and the upper one by means of a micrometer screw parallel to the axis of the bar, the nut of which is secured to the bottom clamp. By this means the elongation can be measured to $\frac{1}{20000}$th of an inch. In a third form two similar clamps without levels are kept apart by a steel rod ending in knife edges. One of the clamps carries a small roller, which turns about an axis parallel to the line joining the steel points above mentioned, and the axis carries a small plane mirror. The other clamp supports a projecting arm parallel with the axis of the test piece, and which presses on the surface of the roller. When the bar is elongated, the mirror is turned through a small angle, and the elongation is determined by a reading telescope and vertical scale to $\frac{1}{100000}$th of an inch. A similar apparatus is used for testing the compression of stone; but in this the compression is multiplied by a lever, and measured by a micrometer microscope to $\frac{1}{100000}$th of an inch.

Mr. C. V. Boys directed attention to some beautiful photographs of the solar spectrum just received from the Johns Hopkins University, which had been obtained by Prof. Rowland's concave gratings.

At the conclusion of the meeting, Prof. Unwin invited the members to visit the Engineering Laboratory of the City and Guilds of London Central Institution, where he broke a bar of Staffordshire iron in the 100-ton testing machine, the force and elongation being automatically recorded.

LEGAL INTELLIGENCE.

Edison and Swan United Electric Light Company v. Woodhouse and Rawson.

This was an appeal on the part of the defendants from the decision of Mr. Justice Butt, delivered on the 25th May, 1886, in an action for an infringement of the Cheesborough patent (No. 4,847 of 1878) for the improved method of charging an electric lamp, and the production of a better carbon for use in lamps. The case, which was heard before Lords Justices Cotton, Lindley, and Lopes, occupied five days in the hearing.

Sir Horace Davey, Q.C., M.P., Mr. Macrory, and Mr. H. G. Rawson, were for the appellants; the respondents being represented by the Attorney-General (Sir Richard Webster, Q.C., M.P.), Mr. T. Aston, Q.C., Mr. Fletcher Moulton, Q.C., and Mr. P. Edward Dove.

Sir Horace Davey, in opening his case, said that without reading the terms of the judgment delivered on that occasion by Mr. Justice Butt, it would be sufficient to say that the validity of the patent in question was established, and that the defendants had infringed it. An injunction and an account were granted in the usual way. That patent was attacked by the defendants on the ground that it was anticipated by several papers that had been published in this country in a publication called the *Chemist*, and they also relied on papers given to the world by a French gentleman named Sidot referred to in the previous trial, and published about the year 1870, the publication of which in this country had been admitted. He would mention at once that the plaintiff's witnesses at the trial agreed that the title of the patent was confined exclusively to incandescent lamps; but Dr. Hopkinson, he thought, expressed his opinion that the title and claims both extended to arc lamps as well. The question he thought would turn to a considerable extent upon the construction to be put upon the patent. According to their contention it was a patent simply for a new material and for a process, and neither the material nor the process of producing it was new at the date of the patent, although it was quite possible and very probable that the person who took out the patent was not aware of what had previously been published in this country. His learned friends, on the other hand, contended, and Mr. Justice Butt seemed to share the opinion, that the patent was for the application of a material, and the process of making that material, to the particular purpose of making the illuminating burners in incandescent electric lamps. The defendants argued before the learned judge that, even if that were so, there was no novelty in the application which would sustain the patent. That was the general nature of the question to which their lordships' attention would have to be invited. It would be necessary to read the evidence at some length, because he thought at the trial, and still held, that his clients got everything they wanted from the plaintiffs' witnesses, and did not put in any oral evidence on their own account. The patent was taken out by a person of the name of Cheesborough, who was, in fact, an importer of the alleged invention, on a communication made to him by William Edward Sawyer, of New York, and Albon Man, of Brooklyn, in the United States, and the title of the patent originally was "Improvements in and relating to electric lamps, and to a method of charging such lamps with an artificial atmosphere, and purifying the same, and to the production of a carbon for use in electric lamps, and for other electric purposes." As altered, the title of the patent was as follows:—"Improvements in and relating to electric lamps and to the production of a carbon for use in electric lamps." As he had said, some of the plaintiffs' witnesses held that the title and claims were confined exclusively to incandescent lamps. He then proceeded to read the specification and to explain to the Court some of the technical details in connection with incandescent lamps, and said that he would paraphrase the description of the patent given in the specification by saying that what the patentee proposed to do for the purpose of making his carbon was to fill a vessel with something—he would say at the moment hydro-carbon gas, although he did not confine his claim to that, and a very important question would turn upon this point. The patentee supposed that he had discovered that the effect of passing a current through the carbon conductor immersed in a bath of hydro carbon gas would be to decompose the gas, whereby a deposit of carbon would be made on the burner. In the first place the deposit of carbon would fill up the pores in the conductor, making the latter denser, or, in other words, getting rid of the porous character of the carbon and making it more homogeneous. When the pores were filled up there would be a continued depositing of carbon on the conductor, which would be thereby increased in size. He further made the remark that if they increased the current there was no limit to the amount of carbon they might get deposited in that way; but he further said that as it increased in size they must increase the current—for this reason, that the amount of heat depended upon the resistance of the carbon, and the resistance varied inversely with the sectional area, so that as the sectional area of the carbon was increased it would require a stronger electric current to maintain the same degree of heat because its resistance would be reduced. There was no novelty alleged as to the mode of applying the carbon and using it. The only novelty which the patentee supposed himself to have discovered—the only discovery which he claimed to make—was the mode of making the carbon, and that would be a very important point in the arguments he (Sir Horace) would address to their lordships. The first claim was for "the herein described method of preparing the illuminating part of an electric lamp, consisting of electrically heating the same, while it is surrounded by a carbon gas or liquid." The second claim was for "the manufacture of the illuminating conductor of electric lamps, produced by electrically heating the carbon in a carbon gas." In other words, the first was the process of making it, and the second was for the material when it was made. That was the construction which

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he put upon the specification, and which he submitted to their lordships. But his contention was that the first claim was for the process which the patentee supposed he had discovered of decomposing a carbon gas, as he called it, by electrically heating, and thereby getting a deposit of carbon on some non-conducting substance. The second was for the material, that was to say for the carbon when it was produced by that process—the material which the patentee described as being of a grey bluish colour and being homogeneous and denser. By the evidence, which he (Sir Horace) would have to read at some length to their lordships, it was, according to his understanding of the evidence, admitted by the plaintiffs' witnesses, that exactly the same process had been described by a gentleman named Deprez in the *Comptes Rendus* in 1849. The material produced by the process described by Deprez was admitted by the plaintiffs' witnesses, as he understood from the evidence, and as he submitted the evidence should be understood to be identical with the material produced by Cheesborough, and he further said that the material produced by Sidot and described by him as "a useful material for electric lighting" was proved to be identical with the material produced by Cheesborough's patent. The reply to this was that Deprez did not point out that the carbon he had produced was used for the purpose of electric lighting. His (Sir Horace's) answer was that what the patentee supposed himself to have discovered was the process or method of making the carbon, and a man could not take out a patent for a particular use of a well-known material produced by a previously known process, unless there was some novelty in the application of it—that was to say, that if he had a particular material he might use it for whatever purpose it was applicable, unless somebody discovered and claimed some particular use of that material which involved invention, ingenuity, and thought in the applying of it. Now, there could be no pretence on the face of this patent when they had got their carbon that there was any thought or ingenuity in the application of it; and the claim, as he had said, was a claim for the method of making it, and not for the application of it, and if it were for the application of it, then his reply was that the patentee had not described any mode of applying the carbon when it was produced, which was different from that already in use. There was a contest whether Sidot referred to arc lighting or incandescent lighting, but whether that gentleman referred to the one or the other it was at least admitted that Sidot pointed out that the material which was admitted to be identical with the material of Cheesborough, although not produced in exactly the same way, was useful, at any rate, for arc lighting, and a French writer, the publication of whose paper in English was admitted, also pointed out that the material produced by Deprez was useful for arc lighting. He (Sir Horace) did not require to go as far as that, for if he could show that the identical method and material had been previously described, that would, according to his contention, carry him as far as he need go. His next point was this, that the specification was hopelessly bad on account of its inaccuracy. Dr. Hopkinson said that to his mind "the illuminating part of an electric lamp" was equally applicable to an arc lamp and an incandescent lamp. His next contention, which would exhaust the points upon which he would address their lordships, was that the specification was insufficient on this ground, that the patentee claimed that he surrounded the conductor with a carbon gas or liquid. Chemists told them that there was no such thing known as a carbon gas or liquid. Dr. Tidy said that that was not a scientific expression, but supposed the patentee to mean some gas or liquid of which carbon was a constituent element. If that were so then there were numerous carbon gases or liquids which Dr. Tidy admitted would not do. There was remarkable proof that the patentee did not know himself what were and what were not suitable things for use, for in one part of the specification, reading between the lines, it was evident that he thought that carbonic acid and carbonic oxide would decompose, with the result of depositing carbon. On the authorities he would show to their lordships that it was impossible to say that the patentee had described his invention with that precision which he ought to have done. Sir Horace then proceeded to read from what he alleged to be previous publications, including the paper of Deprez, already referred to, and that of Sidot, published in the *Chemist* in 1870; one by St. Edmé, in the *Annale Industrielle* later, and another by Sir Wm. Grove, published so long ago as 1847, in the last of which it was shown that if an electric current were passed through a platinum wire in an atmosphere of hydro-carbon gas, the hydro-carbon would be decomposed, and carbon would be deposited.

The Attorney-General contended that if the arguments of Sir Horace Davey were to hold good, it would be necessary to eliminate from the statute book the statute of monopolies, and certainly hundreds of patent cases had been decided altogether wrongly. The way in which the two cases between the present parties, and notably the action now before their lordships, had been conducted, was most extraordinary. No evidence in this case was called on behalf of the defendants. Issues which had over and over again been pointed out by the Court to be issues of fact, and issues of fact with which the Court could only deal on evidence, had been treated by counsel as if they were matters of special pleading, and it had been suggested that the specification had to be construed, and that the issues had to be decided, not upon evidence, but upon the special pleading arguments of counsel founded upon their own surmises as to what the evidence meant. He (the Attorney-General) would go further and say that, if Sir Horace Davey's argument was correct, he must assume and state as counsel to their lordships scientific facts and make scientific assumptions for which there was absolutely no warrant on the face of the evidence. It increased the task of those who had to support patents of this kind immensely if they were to have a completely new departure, if they were to have these issues treated not by dealing with the evidence given at the trial but by suggestions to their lordships that the Court had to find out difficulties. He could assure their lordships on the judgments delivered and acted upon for twenty or thirty years this practice had never been adopted before, and the Courts had not regarded either specifications or patents from that point of view. To take one instance, it had been decided over and over again that if the specification was proved by evidence to be such that a competent workman could carry it out, that was amply sufficient to support the conditions of the patent. The sufficiency of the specification to enable people to carry out the process had been proved by four gentlemen whose veracity Sir Horace did not dispute. There were sitting in court chemists of the greatest experience. On one occasion Sir Horace suggested that an answer given by the witness surprised his chemical witnesses, and yet those witnesses were never called. If his learned friend wished to suggest that the specification was bad because a workman could not understand it, and might be misled into using carbonic acid and carbonic oxide, it was his duty to call evidence, and no suggestion of counsel, however eminent, made evidence that the specification was misleading, when there was evidence that the patentee had explained his invention in a proper manner. This was not the only answer to his learned friend's point as to insufficiency. It was most extraordinary if those who instructed his learned friend had called his attention to the other part of the specification that he had not seen that the point was not open to him, for it was pointed out on the face of the specification that carbonic oxide and carbonic acid would not do, and nobody, according to the specification, could possibly have thought that the hydrocarbon gas or liquid supposed to be employed could by any possibility include that which was in one sense a hydro-carbon, but not in the sense in which the patentee was using the term. Coming to the question of the novelty of subject matter he would again say that the theory of Sir Horace Davey could only be supported by excluding from consideration all the decisions which directly dealt with the point, and by taking a class of decisions which according to his (the Attorney-General's) submission were not analogous. What analogy was there with the Brunel fish plates case? In this case it was not admitted by any of the witnesses that what the plaintiff had done had ever, in fact, been done before. It was never suggested by counsel at any stage of the case in the Court below that the invention of Mr. Cheesborough consisted in applying the current gradually in the sense that the invention would not work without such a gradual application. It was not a fair construction of Mr. Justice Butt's statements, or of the evidence, to say that such was the view put forward. Mr. Justice Butt was stating what was the effect of carrying out Cheesborough's description. He was pointing out that if the current were increased all holes in the conductor would be filled up, and porosities would be got rid of. It would be a most unfair construction of the specification, and one which could not be supported without flying in the teeth of the whole of the evidence, to say that the essence of the whole invention was the graduated current, and that there should only be the application of a graduated current, because it was perfectly possible that with certain conductors the graduated current would not be necessary. With regard to the alleged anticipation, he denied that either Deprez's or Sidot's process would get rid of the porosities in the carbon, and it was just because the porosities could not be got rid of that nobody ever succeeded in making as good a conductor for electric lighting purposes as Mr. Cheesborough described. There were 75 anticipations alleged of this patent, descriptions of electric lamps with carbon conductors, of vacuum lamps of all kinds, specifications actually dealing with electric lighting; but the whole of those had been abandoned, and three publications in foreign journals, which were published in England, were relied upon, having no reference to electric lighting at all, except that Sidot said that for arc lighting some of his charcoal might be used. It was most remarkable, however, that when they came to understand these so-called anticipations it was found that not only did they not show them how to make Cheesborough, but sent them in the wrong direction. Sidot told them to proceed in a way that must result in failure, and Deprez told them not to use the things which were most successful, which, in fact, must be used for the purpose of carrying out the process according to Cheesborough's patent. Nobody prior to Cheesborough had ever shown how to produce the material in the way in which that gentleman ultimately produced it. The outside to which the facts could be stretched by the argument of his learned friend was that a part of the carbon operated upon by Deprez would have some of the properties, or the properties to a certain degree, of the carbon operated upon by Cheesborough. What the defendants had done was to take bodily the Cheesborough patent and improve their lamps enormously. They were not gentlemen who came and said, "By a long process of discovery we have found out how we can get a good carbon." But after the Cheesborough had long been known to the world they said, "We will now by the light of 1886 pick out three obscure publications which have nothing to do with electric lighting, and we will construe these so as to describe that which Mr. Cheesborough made, although nobody has ever produced it, and although one of the most experienced chemists of the day, having read both descriptions, both Deprez's and Sidot's, and desiring to get at the very thing, has tried it and failed. Their lordships could not, and had no power as judges of law and fact to overrule the finding, except upon evidence, when the finding was based upon evidence. The Court below had believed the witnesses called, and a statement was made by the counsel for the defendants that their witnesses would have said the same thing. He thought he could satisfy their lordships on an authority to which Sir Horace Davey never referred, an authority on the question of sufficiency and previous publication, that what was described in previous scientific publications was a question of fact and not of law. However their lordships might be impressed with the marvellous special pleading powers of his learned friend, they would not be justified in over-ruling the sworn testimony of the witnesses called. They were not justified in reading Deprez's paper published nearly thirty years before with the light given by Cheesborough's patent. They would be acting most unjustly in doing so, and contrary to any construction of patent

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law he had ever heard of in the course of a somewhat extended experience. He then proceeded to quote the case of Hills *v.* Evans (31, "Law Journal") and said that if they applied the test there described to the so-called anticipations in this case, those anticipations would be utterly demolished. He could show their lordships that the necessary ingredients for the effective working of what Mr. Cheesborough described were not to be found in Deprez, in Sidot, in St. Edine, or in Sir Wm. Grove, or in all four of them put together. What was the use of citing a case to show that taking a known machine and applying it to a particular use was not subject matter for a patent. He (the Attorney-General) had never said it was. From beginning to end of the case there was no evidence that *de facto* a piece of carbon of uniform section with the porosities filled up had ever been produced before Cheesborough. It was sworn that no such carbon had ever been produced prior to November, 1878 the date of the Cheesborough patent. Prof. Dewar had never seen it, and he had never heard of it being produced, and in 1879, he was trying to get rid of the porosity in the carbon, and knew both Deprez and Sidot; he honestly tried the methods described by those gentlemen, and failed. The Attorney-General then proceeded to read the evidence, the specifications, and alleged anticipations, analysing them as he went along. He contended that no one ever before tried to read a claiming clause without going to the body of the specification to see to what it related. Sir Horace Davey had urged Dr. Hopkinson's evidence in favour of his view, but if he had done what Dr. Hopkinson intimated it was necessary to do, read the specification itself and the claims together, he would have had no difficulty in comprehending what was really meant to be described. With respect to the cases cited by his learned friend, he submitted that not one of them was analogous. First there was the class of case which related to anticipations. They were every one of them cases in which a known machine or a known process producing a certain result was applied in an analogous way, and it was attempted to support the patent for the application of a known machine, combination, or process, to produce either the same or an analogous result Those could have no bearing on a case in which the process described was upon the evidence new, and where the result described had never been attained before. The next class of case was that which bore upon the question of the sufficiency of the specification, and he would cite authorities to show that, from the workman's point of view, sufficiency of specification was a question of fact and not of law. In every one of the authorities quoted by his learned friend evidence was given before the Court that the specification could not be carried out. The last class of case was to show that the specification was not sufficient on the ground that if properly construed it would include something which had been previously published. He (the Attorney-General) had never denied that the Court had to construe the specification and say what it meant, but he submitted that there was no authority which said a specification was insufficient which properly described the process and which did not in terms mislead or tell people they could produce what was previously known.

Mr. MOULTON said that by the arguments that had been used by Sir Horace Davey, an attempt had been made to alter the function of the Court. The function of the Court was to be arbitrator of whether the patentee had performed his duty to the public. The questions that the Court had to decide were these:—First, did the patentee make the invention? Second, did he tell the public how to use that invention? Third, had he told the public the information necessary to make it? The reason why evidence was of such paramount importance in all these matters was that they called in outside people to say whether they could draw from the specification the novelty of any invention. Let them once grant that by accurate or inaccurate, grammatical or ungrammatical language, the patentee had fairly done his duty to the public, to whom he addressed himself, and the Court was obliged to support his claim. This was not a question as to whether a principle of construction applied as in the case of wills. Did or did not the patentee tell the public what it was necessary for him to do, and did they have that knowledge which they ought to be able to derive? And when that was settled as a fact, then the patent was good. Sir Horace Davey made a point on the words "beeswax, balsam, and most oils, if pure, operate satisfactorily—almost any hydro carbon will answer." Sir Horace's objection to the specification was because those words appeared. That was a question whether or not the patentee had given the public sufficient information to carry out his invention—nothing else. That was a question of fact. He was perfectly certain that the Court would be very sorry to test the goodness or badness of a patent by whether they could carry out the directions. Would a competent workman from this specification know how to carry out the invention? That was a question of evidence. Let him examine how the defendants had met that question. The plaintiffs called as their first witness Sir Frederick Bramwell, who said that the specification was amply sufficient to enable a workman to carry out the invention. The next witness called was Dr. Hopkinson, who was not only one of the best electricians in England but a chemist as well, and not a single word in the cross-examination of that gentleman contradicted that statement. Then came Dr. Tidy, who said, "I say that the strict meaning of the word "hydro-carbon" limits it to things with only hydrogen and carbon, but by the introduction of the words beeswax, balsam, and oils he (meaning the patentee) did not use it in the strict chemical sense. Then came Prof. Dewar, and there was not one single question put upon this point. The same might be said with regard to Mr. Imray, and now at the end of the case Sir Horace Davey asked whether the defendants were not going to call in other witnesses because their chemists could not carry the matter further. How could the other side come to argue as a matter of law that that was insufficient, when they had not got one single person on either side who said that there was the least difficulty in applying the specification from the point of view of the workman? They had got to consider the question of fact—What was the information that the public could get from it? They had only got the evidence of one of what was understood by Deprez before the date of the patent, and that was in the passage referred to by Lord Justice Lindley:—"Deprez found that by the use of a battery of 500 to 600 Bunsen elements every carbon is softened, and finally converted to graphite in an electric arc—in a galvanic arc." Therefore, the only impression that was made on the mind of the person who issued this was not the effect of passing a current through the carbon, but that if they pushed the carbon into an electric arc it got converted into graphite. With regard to Sidot, his contention was that the material produced was of entirely different physical constitution.

Sir HORACE DAVEY said it was somewhat extraordinary, if his opening argument was of so entirely revolutionary a character as had been represented, that it should have taken four days to answer. His learned friends never wasted time, of course, and he could only assume that on consideration they found the argument more important than appeared at first sight. He was not entitled to the compliments which the Attorney-General and Mr. Moulton had paid him, for, owing to the inadequacy of his power of expression, he had failed to convey to the minds of his learned friends the points upon which he founded his case. The consequence was that for the greater part of four days they had been engaged in the amusing and, perhaps, exhilarating game of setting up men of straw for the purpose of knocking them down, and for that reason he would not trouble their lordships with every point which his learned friends had addressed the Court upon. He and his learned friends who were with him at the last trial might have been wrong in taking the course they did, but why the Attorney-General complained of it he (Sir Horace) could not imagine. His learned friends appeared to have entirely disregarded and contradicted what their own witnesses had said. He considered it to be the duty of counsel, if their own witnesses could not carry the case further than the statements made by eminent men who were called on the other side, to acknowledge it, and to say, "We accept the statements of your witnesses as to points upon which we rely, and we therefore will not trouble the Court by proving over and over again what has been proved by your witnesses." Let him repeat once more what were the points on which he relied, and which he said raised an important question of law. Sir Frederick Bramwell said there was nothing in Cheesborough's patent which was not to be found in Deprez's except the direction as to the maintaining of the temperature. If he had called a dozen witnesses he could not have gone further than that, and he wanted no more than that. Of course that raised the question of law whether the publication of Deprez's paper in England was such an anticipation of the patented process and material as would avoid the patent. That was a perfectly fair argument, and one upon which their lordships would decide. Dr. Tidy, Prof. Dewar, and Dr. Hopkinson all agreed with Sir Frederick Bramwell, and that being so, there was no object in his calling witnesses. Prof. Dewar laid more stress upon the graduated current, and he endeavoured to show that Prof. Dewar used the expression not as relating to the maintenance of the temperature beginning comparatively low and going up to an intense heat. In the patent they would find the direction to maintain the temperature by increasing the current as the carbon increased in size, which was quite different from what Prof. Dewar said. If he (Sir Horace) misunderstood the evidence of Prof. Dewar, and that the latter was speaking only of a gradual increase of the current—if that were so he went no further than Sir Frederick Bramwell, who said, "I find nothing further in Cheesborough than in Deprez, except the direction to increase the current in proportion to the increase in the size of the carbon." If more than that was meant he (Sir Horace) contended that there was no such direction in the patent.

Their Lordships reserved judgment. Our readers will remember that judgment is also reserved in the previous trial.

The Brighton Electric Railway.—Simmonds v. Volk.

At the Brighton County Court, on 21st inst., Judge MARTINEAU gave judgment in the above case which was tried in this court about a month ago. Action was brought against Mr. Magnus Volk, the proprietor of the electric tramway system on the Brighton beach, by Mr. Joseph Simmonds, of 148, Eastern-road, on account of damage inflicted upon his son and his son's bicycle, which were both upset and injured by a restive horse alarmed at the whistling of a passing electric tramcar. In the course of the evidence it was shown that the youth was attempting to pass the horse on the near side, and that if he had kept to his proper side the horse would not have touched him. On the other hand, it was alleged that horses were frequently being frightened by the tramcars, and a good deal of evidence went to show that there was an organised opposition to the line by persons who looked upon it as a nuisance. A strong point was made of the fact that the railway had not the parliamentary or Board of Trade sanction which would exempt it from responsibility for accidents of this kind; and the plaintiff's solicitor went so far as to contend that it was an illegal railway, notwithstanding the Corporation's sanction.

After several weeks' delay, his Honour gave judgment for the plaintiff, with costs. He said this was an action to recover £30 as damages in consequence of the alleged illegal and negligent driving of the tramcar by the defendant's servants, and £7. 10s. was also claimed as special damages. The plaintiff's case was that he was riding a bicycle along the Madeira-road, and that the tramcar caused a horse to shy and to run into the bicycle, with the result that the plaintiff was upset and received such injuries as rendered him unable to work for some time. His bicycle was also broken and his clothes damaged. The evidence called on both sides was voluminous, the plaintiff's advocate contending that the car constantly caused horses to shy, and, on the other hand, it was contended that very few horses shied at the car,

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and that it was no more unsightly to animals than an ordinary vehicle. His Honour in reviewing the evidence said no doubt some of the witnesses on each side were biassed. Some perhaps had had their profits decreased by the tramcar, and others were biassed as witnesses very often were, perhaps through a controversy in the Town Council, or in the town, or something of that sort. He, however, thought there remained a large body of evidence showing that there had been shying, and if accidents did not constantly happen, they were likely to happen. One reason, perhaps, was that the Brighton horses got used to the car and took no notice of it. He, however, was of opinion that it was a nuisance and danger to the safety of passengers going along the road, and it was admitted that the railway was not under the authority of an Act of Parliament or the Tramways Act. He was of opinion that the defendant was responsible for the injury caused to the plaintiff, and the only question that remained was as to damages. He assessed the damages at £20, and as the matter involved in the action was of general and public interest, he directed the costs to be taxed on the higher scale. Mr. Olding, who appeared for the plaintiff, applied for an injunction restraining the defendant from running the electric cars in future, but his Honour refused the application then, giving leave to apply at a future date.

We learn with reference to this case that some influential inhabitants of Brighton, amongst whom are the Vicar of Brighton, J. H. Puleston, Esq., M.P., B. B. Hodgson, Esq., and Captain Price Hamilton, have already promoted a local subscription to enable Mr. Volk to appeal against the judgment, which, if enforced, would probably result in an injunction being obtained to close the line altogether. The circular which Mr. Volk's supporters are signing states, among other things, that "The line has been a great success and attraction to the town, a convenience to residents, and has been maintained at his sole risk for nearly four years against great difficulties and frequent damage from storms, and it is felt that this public testimony will be an encouragement to Mr. Volk to persevere in his undertaking, and a practical demonstration of the desire of the public to prevent the line being closed altogether." With a view of securing a large number of supporters small subscriptions only are asked for.

Macdonald v. Alfred Slatter and Co. (Limited).

In the Lord Mayor's Court on Wednesday this case was tried before the Recorder (Sir T. Chambers, Q.C.) and a jury. The plaintiff, Mr. T. M. Macdonald, sought to recover damages from the defendant company, who are electrical engineers, carrying on business at Sekford street, Clerkenwell, for wrongful dismissal from the position of secretary.

Mr. Lewis Glyn (instructed by Mr. W. Wild, of Leadenhall-chambers, St. Mary Axe) was counsel for the plaintiff; Mr. Harper appeared for the defence.

The plaintiff, in his evidence, said that he had been a friend of Mr. Wild, who was originally the plaintiff's solicitor, and by him he was introduced to Mr. Alfred Slatter, the managing director of the defendant company. He was engaged to act as secretary of the company at a salary of £100 a year. That was very small; but it was arranged that if plaintiff worked hard in the interests of the defendants he would ultimately be in receipt of from £300 to £400 per annum. Everything went on all right until the 19th of October last year, when he received a letter addressed to him by Mr. Slatter, saying that in consequence of slackness of trade he would have to leave at the end of the week. The letter also said that the defendants would be pleased to recommend him to any future employer. Plaintiff spoke to Mr. Slatter on the subject, and an interview at the works in Sekford-street was of a very stormy character. Plaintiff presented himself at the defendants' place of business, when he was met by Mr. Slatter, who simply pushed plaintiff into the road. He could not, however, obtain any extension of the notice. As secretary of the defendant company, he claimed to be entitled to six months' notice —£50. While he was in the defendants' employ he habitually worked overtime, frequently remaining at the office until nine, ten, or eleven at at night. He mentioned that to Mr. Slatter, who said that plaintiff would not be forgotten. He had never been remunerated for that extra service, and he now claimed nineteen guineas on account of it.

The plaintiff was subjected to a long cross-examination, which went to show that he had really been employed as a bookkeeper, and that he had been incompetent to act in that capacity. He denied ever having been insolent to Mr. Slatter. He kept the petty cash, and at times Mr. Slatter would borrow money from it, giving receipts for it. This amounted to about £15 when plaintiff left. On one occasion Mr. Slatter broke open the drawer in which the petty cash was, and also the cash-box. Since then Mr. Slatter had a key of the box in which plaintiff kept the petty cash. He knew that the defendants said he had not accounted for £7 for petty cash, but that was not true.

For the defence it was pleaded that the defendant had received sufficient notice, and that he was really not entitled to any in consequence of his misconduct. Mr. Slatter said that the plaintiff was engaged as bookkeeper and not secretary at all. It was quite true that witness had given a letter to the plaintiff saying he would be pleased to recommend him, but that was written before witness knew of the state of the books. After the letter was written, the plaintiff went to the works and created a disturbance. He assulted witness first by endeavouring to enter the office, and witness had to call a policeman to have him removed. Witness denied breaking open the cash box, and also that the plaintiff was entitled was entitled to six months' notice. With regard to the overtime which plaintiff alleged he had worked, that was because the plaintiff neglected his duties during the day, and had to make up the time in the evening. There was not sufficient work to retain the plaintiff so long, because the business was but a young one, the turnover being only about £700 per annum. Witness was the managing director. There were no other directors.

The jury found for the plaintiff for the nineteen guineas, and also for three months' salary in lieu of notice, namely, £26. They also added that the charges of misappropriating the petty cash made by the defendant against the plaintiff were unfounded.

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The twenty-ninth half-yearly ordinary general meeting of this Company was held at Winchester House, No. 50, Old Broad-street, London, on Thursday, January 20, 1887, under the presidency of John Pender, Esq.

The SECRETARY (Mr. George Draper) having read the notice convening the meeting, and the minutes of the last meeting and the report having been taken as read,

The CHAIRMAN said: Gentlemen, before asking you to pass the first resolution I will, as usual, make a few remarks. The revenue for the six months ending the 30th of September, 1886, amounted to £292,229, against £331,419 in the corresponding period of 1885, or a decrease of £39,190. This reduction is divided as follows:—Indian and trans-Indian £9,000, Egyptian £23,000, Portuguese, Spanish, Turkish, &c., £9,140; less ½ per cent. extra dividend on Eastern and South African Company's shares, £1,950, bringing the net decrease to £39,190. With reference to the decrease of Indian business, about £4,000 of the £9,000 may be put down to the reduction of tariff from 4s. 7d. to 4s. per word, which we made on the 1st of July last. The falling off in our Egyptian traffic is caused by the general quieting down of that country. Consequently, there being no news of importance, the London papers have almost ceased to send special messages, and Government messages are not so frequent as they were last year; but at the same time I am glad to mention that there is a slight increase in our commercial business with Egypt, which augurs well for the future if peace is maintained and a stable Government established there. Of the falling off in our other traffic, about £7,000 of the £9,000 may be put down to the very large reduction in the tariff which we were forced to make at the Berlin Conference of 1885, which came into operation on the 1st of July last. As you are aware, we are dealing with the accounts up to September last, and they embrace three months of the reduced tariff. The total working expenses during the six months amounted to £81,025, against £86,935 in the corresponding period of 1885, being a decrease of £5,910. The general expenses in London were £7,964, against £7,905, or an increase of £59. Rents and taxes show an increase of £340, and repairs, furniture, &c., an increase of £360. Full explanations of these increases were given at the last meeting. On the other hand, salaries and wages, office expenses, stationery and printing, and law charges show decreases amounting in the aggregate to £681. The working expenses at the stations were £58,129, against £60,497 in the same period of last year. Most of the items under this head show considerable decreases, so that the net reduction in station expenses, as compared with 1885, is £2,368. The expenses attending the repairs and renewals of cables amounted to £53,965, against £45,288, or an increase of £8,677. Our repairs, as you will observe, have been exceptionally heavy this half year, more especially on the Direct Lisbon line, where the steamer "Electra" had to lay in 191 miles of new cable. This, with the portions renewed in previous years, completes the renewal of three-fourths of this line; and that, you will observe, is practically renewing this line out of revenue—maintaining the line in a thoroughly efficient state. It will be seen on reference to Abstract C that other important repairs have also been effected by our ships, particularly the repair by the "Mirror," of the Zante-Canea cable, which was broken by an earthquake, necessitating an expenditure of fourteen miles of new cable to restore the communication. After charging all expenses, including income tax, providing for interest on debentures, debenture stock, and preference shares, we are, I am glad to say, able to maintain our dividend of 5 per cent. per annum. We carry forward to next account £13,091, against £32,540 in the corresponding period of last year, and judging from our present traffic we may at least hope to carry a fair amount to reserve at the end of the financial year. Gentlemen, these are the hard facts connected with the working of the system during the six months.

I may now give you probably a little more information—information which I believe will be rather of a cheerful nature than otherwise. I have received several letters asking whether there is not some mistake in the amount which the writers had received. In other words, they expected the amount to include the half-yearly bonus, and they were disappointed at not receiving it. I have perfect sympathy with them, and I hope the question of bonus is one of delay rather than of loss; but that will be seen in the next six months. You are aware that when we first agreed to deal with the question of bonus we settled that it should always be kept apart from the dividend—that we should try to maintain a 5 per cent. dividend, which would be a reliable dividend, and that the bonus might be a fluctuating item. After having received it for a certain time, you naturally begin to think that no change could possibly occur to take it away. But I may tell you that at the Berlin Conference we were obliged to agree to what reduced our income by an amount of £40,000 a year, and that £40,000 is about the amount of the bonus. I have mentioned to you on many occasions that any immediate reduction of tariff is a present loss to the company. It requires time to recoup, and I have no fear that we shall recoup it in a short space of time—probably shorter than most of us suppose. Since the end of September we have

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found a very considerable improvement in our traffic, though, until I meet you six months hence, I am not prepared to state whether you will have a bonus or not. If, however, we go on as successfully as we have in the last month or two we shall have done two good things—we shall have reduced the rates, benefiting the telegraphing public, and we shall not have reduced in any way the return to the shareholders. I dare say the improvement in trade has been observed by many gentlemen here. I have often said, and I will repeat it to-day, that telegraphy is about the best barometer of trade we can possibly have. The barometer is rising, our traffics are increasing, and consequently, I suppose, the improvement in trade must be pretty general. I have shown you that our loss on the Egyptian traffic alone last half year was something like £23,000. That is a very large sum. We may not be able to recoup the whole of that, because a deal of it sprang out of exceptional circumstances ; but if trade improves, as we expect it will, I think we may recoup it to a considerable extent.

There is another question I must point to, and it is practically beyond the control of the Directors. I refer to the heavy expenses of repairs. But there is a certain comfort even in that. To *know* that we can repair our cables is a great satisfaction, and we have now had a long experience, and by being able to repair them we may hope to prolong their "life" to an extent beyond what was originally calculated. When I tell you that one of our ships was employed day after day during five months to maintain our cable between Lisbon and England, you can see that, even though there are great difficulties in repairing the cables, there are generally satisfactory results. Speaking on that point, and looking to the future, a duty devolves on us of being ahead of all requirements in this company ; and I think I may shadow forth that, looking to the wars and rumours of wars that are now abroad on the Continent, we must also look ahead and be prepared, should war break out, to be entirely independent of all our land system existing through France. We must rely entirely on our submarine system. We must, therefore, look forward at no distant time to make ourselves thoroughly independent in our system between the Land's End, Gibraltar, and Malta. That we have in view. I have no proposal to make to you now, however. In times past we generally have had our ships and our cables ready when required, and it is the intention of the Board to be in that position in the future should any great Continental war occur. Gentlemen, we have got another string to our bow should anything occur. We have secured a very large, a controlling, interest in the Direct Spanish cable. Through the energy and perseverance of our Managing Director, Sir James Anderson, that Company have obtained a legal decision which will enable them to reduce the capital, and we shall in the future receive a dividend on the reduced capital. It is living in this respect, and also in another respect. Should war break out the chances are that we shall be able to connect with that system our cables in the Mediterranean, and thereby give us an alternative line in the event of our line through France being inoperative. All our cables are at the present moment in good working order. That is a source of great satisfaction, and we are now about to lay a short cable from Gibraltar to Tangiers. I hope before the week ends that that work will be completed. That is taking possession of another important link in the chain of telegraphy which is likely to be materially extended along the west coast of Africa.

Gentlemen, we are going to have a conference in London within the next few months with the representatives of our colonial possessions. As you know a large amount of our traffic comes from our connection with the Eastern Extension Company, who carry our telegraph system to our colonies beyond India to Australia, &c. The question of the mode of cheapening telegraphy will be discussed at that conference. We have got a scheme—I believe a sound and the only practical scheme—for reducing the price of telegraphing to those very distant places. You can well understand that 10,000 miles of cable cost a large amount of capital, and require a large traffic to allow a reasonable tariff. The Eastern Extension and the Eastern Companies will submit a scheme which we hope will reduce the rates by something like a half or even a fourth of the present tariff, leaving in the hands of the Government the power to regulate those rates, and securing for the shareholders a permanent and guaranteed dividend. If we can carry out that proposal we shall have placed submarine telegraphy in the position which it ought to occupy, being, as it is, one of the greatest and most important contributions which science has given to civilisation during the long reign of fifty years of our Queen. If we can carry out that successfully, we shall have done a good work, and all those who are connected with submarine telegraphy may feel proud that they have been associated with a system which has been so universally beneficial. With these remarks, gentlemen, I beg to move :—"That the report and the accounts of the Directors to the 30th September, 1886, submitted to this meeting, be and the same are hereby received and adopted."

The VICE CHAIRMAN (the Marquis of Tweeddale): I beg to second the motion.

The CHAIRMAN: If there is any gentleman who desires to put any question before I put the resolution I shall be very glad to give him the best answer in my power. No one rising to address the meeting, he continued: Those in favour of the resolution will please signify the same in the usual manner. To the contrary. Carried unanimously. The next resolution I have to put before you is as follows :—"That George Garden Nicol, Esq., who now retires, be and he is hereby re-elected a Director of the Company." I am sorry to say that Mr. Nicol is not present to-day. He is much in the same position that I was twelve months ago, suffering from a very severe bronchial attack. Knowing that he has been such a regular attendant—and he has been one of the Directors from the commencement of the Company—I regret his absence. I am quite sure that you will confirm his re-election.

The MANAGING DIRECTOR (Sir James Anderson): I beg to second the resolution.

The CHAIRMAN put the motion in the usual way, and declared it carried unanimously. Continuing, he said: The next resolution is "That John Denison Pender, Esq., who now retires, be and he is hereby re-elected a Director of the Company."

Lord SACKVILLE CECIL: I beg to second that.

The CHAIRMAN put the motion, and it was carried unanimously. Continuing, he said: Gentlemen, in proposing my son, you all know that my name has always been associated with these companies. I am getting on in years now, and I should like to leave behind me my name still associated with the companies. Young blood may do well in the future, but if you want to be useful in a career you must train for it among those of greater experience.

Mr. GIBB: I beg, gentlemen, to move "That Mr. Henry Dever, and the firm of Messrs. Quilter, Ball, Crosbie, Glegg, and Welton be, and they are hereby elected auditors of the Company for the current year, with a remuneration of £100 each."

Mr. STARNS: I beg to second that.

The CHAIRMAN put the motion in the usual manner, and declared it carried unanimously, adding, that is the business of the meeting. I am pleased to see so many here to-day.

Mr. HIRST: Before we separate I think we ought fairly to pay a compliment to the Chairman and the Directors for their anxious and earnest efforts in discharging the business of the Company.

Dr. WALLER: I was going to do so. I rose for that purpose.

The CHAIRMAN: Probably you will kindly second it.

Mr. HIRST: Because a gentleman meant to propose a resolution and was disappointed in that, there is no reason why he should not second it. (Laughter.) Even if there is any gentlemen present anxious to speak on the subject we shall be glad to hear him supporting the resolution. There has been, and must have been a great deal of difficulty in maintaining the affairs of the Company, especially during the past year. I can remember our worthy Chairman delivering a lecture some years ago before a learned society in this city, in the course of which he stated that reduced tariffs could scarcely answer with respect to telegraphy. That was the impression then, and I believe it was perfectly correct then ; but with a reduced tariff to secure our dividend it must require a great deal of skill and management on the part of the Directors. I think without my saying anything further you will give a unanimous vote of thanks to the Chairman and Directors for the admirable manner in which they have conducted the business of this Company.

Dr. WALLER: In seconding this resolution, I beg to assure the gentleman who has moved it that I feel no disappointment whatever at his having anticipated me, and proposed the resolution in a manner far better than I could. I shall only add a word or two to the observations which he has made. It is little needful, indeed, in moving a resolution such as this almost to say anything, for our long experience of the manner in which you and your Directors have conducted this enormous undertaking gives us the greatest confidence that in any of its trials, such as you have commented on to-day, should they arise again, we know that we are in the hands of gentlemen of great experience, of great knowledge, of great ability, and of industry and of vigilance. Sir, you made one observation which was almost a painful observation to me, having known you so long. You talked of advancing years and possibly of leaving another to take your place as he takes your name. It is true that young blood has its advantages, but an old head and an experienced mind more than counterbalance the advantages of young blood. On this Board we have the good fortune to unite all these advantages. We have the old heads and experienced minds, and the great knowledge, as well as the "go" and vigour of youthful blood. Having said these few words, I commend this proposal to the earnest, sincere, and heartfelt acceptance of every shareholder in this room.

The SOLICITOR (Mr. Burt) put the motion, and it was carried unanimously.

The CHAIRMAN: I assure you, on behalf of my colleagues and myself, that I thank you most sincerely. The remark that I made in regard to my age I may qualify in this way—that I never felt better in my life (hear, hear), or more equal to the business before me, or more ready for a fight, if a fight becomes absolutely necessary. Therefore do not suppose that I am showing the white feather in any way ; but I think it is only prudent of us all not to be satisfied with "sufficient for the day," but to look forward to men who will by-and-bye occupy the positions which we now fill, and to see that they have during the interval gathered from the old heads that experience which is so absolutely necessary for them to carry on such a great enterprise. We have done an enormous amount in the way of bringing together the different nations of the world. If I were to go on and give you some details of that it would probably startle some here. We have occasion in this Jubilee to refer to this submarine telegraphy, and the great progress which the science has made during the period of the Queen's reign. I will not, however, trouble you further to-day than to add this—that you may rest assured while the gentlemen on this side of the table have good health your interests will be managed in a way that I am sure will at our half-yearly meetings receive your full recognition, as has been the case to-day.

The proceedings then terminated.

Direct United States Cable Company (Limited).

The nineteenth ordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, on Friday, January 21st., 1887, under the presidency of John Pender, Esq.

The SECRETARY and TRAFFIC MANAGER (Mr. J. W. Fuller) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, I presume you will take the report as read (it has been in your hands for some days), and, if so, I will make my

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usual remarks on the working of the business during the last six months. The revenue for the half-year to the 31st December last, after deducting out-payments, amounted to £19,603, and the working and other expenses, including income-tax, but exclusive of the cost of repairs, absorb £16,354, leaving a balance of £3,249 as the net profit of the half-year, making, with £3,051 brought from the previous half-year, a total of £6,300. Out of this total there has been paid an interim dividend of 2s. per share for the quarter ended the 30th September last, leaving a balance on the revenue account of £229. A further interim dividend of 2s. per share is proposed to be paid for the quarter ended the 31st December. This will require, in addition to the revenue balance, an amount of £5,842, which will be principally paid out of the interest on the reserve fund investments. You will see, gentlemen, that we do not interfere at the present moment with the reserve fund. We are anxious to keep up a small dividend. We know that this fight is a severe one and very onerous, too, and we desire, if possible, to make it as light as possible upon our shareholders. We have therefore declared this small dividend, but we have been obliged to assist the revenue by taking a certain amount, as I have told you, from the interest on the reserve fund to make up the dividend we are now going to declare. The revenue at the sixpenny rate shows a falling off of £18,512, or about 49 per cent. as compared with the corresponding period of 1885, when the tariff was 1s. 8d., but the actual traffic in words carried by the associated companies has increased by 133 per cent. The Atlantic traffic as a whole, however, including the Commercial Company, has probably not increased more than 80 to 85 per cent. We know our own affairs, gentlemen, but we do not know exactly the amount of traffic that has passed through the Commercial Company's cable. As you are aware, their rate is 1s. and ours is 6d., and we are very much disposed to attribute the very large increase which we have had to a very considerable decrease in that Company's returns. The working expenditure in London is somewhat higher than in 1885, owing principally to the removal of the Company's offices into others more commodious and extended. The expenses at stations are also slightly higher, chiefly through the item of stationery, the large increase of traffic having rendered necessary an additional supply of message forms and other stationery. On the whole, however, the working expenses and other payments show a reduction of £278 as compared with 1885. The reserve fund, after being credited with interest on the investments, and debited with £2,479. 8s. 11d., the cost of the last repairs of the short section of cable, now stands at £328,183; and I may mention that even if you take the market cost of our cable to-day, and along with it your reserve fund, your property is a valuable property, and about the cheapest cable existing at the present moment. The investments which we have made for the reserve fund are considerably higher to-day than the amount they cost to the Company. These are something of the dry facts connected with the working of the last six months. It is now my duty to make a few remarks, and to give you all the information within our power, or all the information that it is desirable to give at the present moment as to the position of the Company. I know that there are many of you who are watching very carefully the contest that is now going forward. I think for the last two years at our meetings I have been talking of this competition. There are gentlemen at present here who have always urged that we ought to put down our feet firmly, and meet such competition in the only way that it ought to be met. I have stated on previous occasions, when we were paying you a 5 per cent. dividend, and carrying forward a comparatively moderate sum, that that was not a dividend which, in my opinion, could be considered a very large dividend, looking at the nature of the investment. Still, in face of that, another company came in, and they practically took away from us not only their proportion, but something more than their proportion of the traffic. You may naturally ask us why do they take away that proportion? The answer is, simply because they posed as the pioneers of a new departure—a new system of cheap telegraphs; and the consequence of that was that, with the reduction from 2s. to 1s. 8d., they gathered a very large amount of support from the telegraphing public. Now, gentlemen, if that reduced rate had given them a large return, one would have thought that it was not bad business, but the reverse has been the case. They have entered upon a field which was fully occupied—occupied largely in excess of the telegraphing requirements of the day. There is only a certain amount of money earned from Atlantic telegraphy, and that has been the case upon the average for the last two or three years. You may reduce the rate, but you do not increase the money. Consequently the amount taken away by the new company, something like £170,000, was practically thrown into the sea, without giving any benefit to them, but at the same time doing serious injury to us. That posing as being the parties who reduced the rate got them a considerable amount of sympathy and a very large amount of traffic. They were also managing their business in a different way from what we did. They were doing things, which secured traffic, but which we had not been in the habit of doing. The consequence was, as I said before, that they got a very large amount of traffic, and we were obliged, as you know, to reduce our dividend from 5 to 3 per cent., and to carry over something like £3,000 instead of £30,000 to the reserve fund. In other words, gentlemen, we found that every day we were getting into a worse position, and that the only alternative was to go to such a rate as would be most disadvantageous to them, but, I may also say, a non-paying rate for ourselves. In adopting that rate we had two influences at work. The first was that we should probably induce them to come to an understanding. We tried very hard to come to an understanding with them as to the rates before we reduced to sixpence, but the negotiations resulted in nothing practical, and we were obliged to go down to a 6d. rate. In going down to sixpence we knew this—that if we were doing some harm to ourselves at the present moment, we should be doing a great deal of good for ourselves in the future. We knew we should increase telegraphing considerably, and the result has been an increase of something like 130 per cent. in the traffic. Still, that does not give us a return sufficient to warrant us in changing the rate at the present moment. There is no use, to my mind, in going up from sixpence until we can go to a point that will give you a fair and moderate dividend, and at the same time maintain our reserve fund. That is the position we occupy to-day, and that is the position which I ask you to support us in carrying through (Cheers.) I know when we began this competition I stated that it might be possibly twelve months before it would come to an end. We have gone on for eight months, and probably it may take some time yet before it ends; but this I am confident of, that those who have stepped into this field—stepped into it, I believe, without thought, and without giving it the attention they ought to have bestowed upon it, stepped into it, induced by fair promises of large dividends and of great results—are beginning by this time to find that they have made a very great mistake. I may tell you that some years ago, when the French Company was promoted—prompted by the same spirit which has promoted the present Commercial Company that is opposing us—I went over with some of my colleagues to Paris. We went into the counting houses of the men who were promoting that French Company, and gave them a true and honest statement of what would be the result of their enterprise. I said that within two years the money they were spending would not represent in the market one third of the expenditure they were then going to. The result has been that to-day the French Company's cable is not worth one fourth of what it originally cost. That fact shows that there is no very great encouragement for Atlantic telegraphy, but in the face of that result—because that result was pretty well ascertained before the Commercial Company came into existence—the very same gentlemen who promoted that French Company have induced Mr. Mackay, with his long purse, and with his very great intelligence, too, to go into this enterprise. You may ask me, how long is this going to continue? I would say that a great deal depends on the length of Mr. Mackay's purse. I believe his judgment is sound, and that he will very soon realise that the picture presented to him of returns of 16 and 20 per cent. will probably have the same result which the French Company have shown in their work since they were formed. If that strikes him as I hope it will—and I think that in all probability it may strike him very soon—Mr. Mackay is too wise a man, and knows the value of money too well, to continue this fight to a disastrous end. I think that our position is very much stronger than theirs, and, consequently, I hope the shareholders will support the Board in maintaining the position we have taken—taken most reluctantly, but still in the belief that it will serve the best ends of the Company in the future. (Cheers.) Now, gentlemen, I have referred to the French Company. That company formed part of the "pool" during what I may call the fairly good times of this Company. They never earned anything like the amount that they received from the "pool," but their relation with the associated companies was perfect. M. Pouyer-Quertier was at that time president, and conducted the affairs of the French Company, and his relations with us were all that we could desire. That company has, however, changed hands. I believe the influence and the money, to some extent, of the Commercial Company have got possession of the French Company, so that they are now what I may call operating it. While posing as the great reducers of tariffs before the public and gaining *kudos* by that, the French Company—the new direction—have been most anxious, have urged us in every possible way, to return to the old rate of 1s. 8d. We saw naturally that those who were advising them were feeling the strain now placed on them by the low tariff they are obliged to work at. We thought the time had not come for making any change, and we told them so. The result has been that they have intimated to us that they will retire from the "pool," and that the agreement is at an end. As you know, that is not the way that English gentlemen deal with business. They have no right whatever to retire, but if they do retire they are bound in honour, and legally, I believe, according to French law, to repay us all that they have received from the "pool" in excess of the amount they earned, and that is something like £250,000. Therefore, you see, if they are not prepared to maintain their bargain in an honourable way, they are bound to pay in another way. That will not be a very bad transaction for the other associated companies. Before I meet you again probably I shall be able to give you some more information on this question. I hope they will not be so foolish as to go into litigation, but if litigation is to be the order of the day we are quite prepared to fight them, and to maintain your interests in their entirety. I think I have now given you pretty well all the information in regard to our relations with the French Company and the position that we have taken up and desire to maintain until we see more of the working of it than we do at the present moment. To show you what a tempting field the Atlantic is, while we are working at a sixpenny rate and all our stocks at 50 per cent. discount in the market, and some of them even lower, we find another Company coming into the field to take part in this grand scheme of carrying Atlantic telegraphy, for something less than nothing I presume. That Company has been promoted, and the men on the Board are, at all events, men of very high position indeed—men whose names are well known in the City and in the West End. How they have gone into such a scheme I cannot understand. It must be an infatuation. There is something connected with Atlantic telegraphy which I cannot exactly explain but there is an attraction there which has drawn those men into this position. If they had come to us I would have given them the same information that I gave to the French financiers to whom I have just referred, and I would have shown them how my prophesy in that instance had been realised. They did not choose to come to us, however, or, as far as I can learn, make the necessary inquiries. They have appealed to the public, but if I am correctly informed the public has not responded. I think, however, after what they have learnt, even since they came before the public, that if the public had responded and given them all the money they required, those gentlemen would have thought twice, and more than

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twice, before they expended the money in putting the cable into the Atlantic. I do not think we need fear any opposition from that quarter. We have a very formidable opposition to deal with in Mr. Mackay, but I have a strong belief that when men such as those on this side of the table and Mr. Mackay—who is a thoroughly business man, and who has made his own position and fortune—begin to thoroughly realise that we are throwing money away—money which they can never recoup—they will take a common-sense view, and we shall by-and-bye meet and discuss this question with a view to a settlement that will be satisfactory to all parties. We have already discussed the question with them. We have even told the French Company, who are now retiring from the pool, that if they choose we will meet them and discuss a question of tariffs that shall be satisfactory to the shareholders as well as to the general public. That, for the moment, has been declined. I do not think the contest can go on very long, but while it does let us fight with earnestness and with the belief that the contest is to bring about a result that will be more satisfactory to the Company than if they were to enter into any compromise at the present moment. With these remarks I beg to move the following resolution :—

"That the report of the Directors, dated 7th January, 1887, together with the statement of accounts for the half-year ended 31st December, 1886, annexed thereto, be and the same are hereby received and adopted."

Mr. William Ford seconded the resolution.

Mr. Guesdon—who commenced by stating that he had "a few remarks" to offer, and who then addressed the meeting for half an hour—said that although on commercial and moral grounds he had deprecated the competition that was going on, now that they were committed to it he would not advocate shirking from it. It must be carried out, like all wars, to the bitter end ; but when the Chairman said that the Directors had tried every means to come to an arrangement with their competitors he had forgotten to mention the conditions sought to be imposed. The Chairman had spoken about the injudicious application by Mr. Mackay of his capital ; but that was no part of their business. If that gentleman thought he saw an opening for conducting a business for himself, and perhaps to dissociate his name from "the Great Bonanza," and be known in Paris—where he was living in very good style —as Mr. Mackay of Atlantic telegraphy, he (the speaker) would find no fault with him, and he had defended Mr. Mackay's proceedings from the beginning.

The Chairman : I have not said one unkind word of Mr. Mackay.

Mr. Guesdon repeated that he thought the Chairman had gone a little out of his way in saying that Mr. Mackay might have made a better use of his money. Continuing, he argued that there had been a good deal to provoke public hostility in connection with cable enterprise, and he wished to know the nature of the proposals made to Mr. Mackay as to the question of tariff. In view of the value of money, he (Mr. Guesdon) thought that 5 per cent. interest should be considered highly satisfactory ; but what was wanted by the Direct Company was not a return of 5 per cent. on their cables, but a good profit on the ledger value of them, which was a very different thing from their intrinsic worth. He afterwards contended that the intrinsic value of the capital of the Anglo-American Company, of the Direct Company, and of the French Company was worth about 10s. in the pound. Like others in trade, they must submit to the reduction in the value of their goods; and they could not expect to pay a large dividend on such an enormous capital as that of the three companies mentioned. The Direct Company, he afterwards contended, could not exist as a single cable company, and therefore had to be affiliated to other companies, whence he proceeded to argue that the expenses were too high, especially so as regarded the remuneration of the Directors, particularly as, owing to the dependence of the Company on other companies, the position of the Board was, in his opinion, "a sinecure, pure and simple." Even if the shareholders were receiving a good dividend the Directors were handsomely paid, but as the former were getting so little the question of the Directors' fees was most unsatisfactory. In the first half of 1886, the earnings of the company showed a profit of 4s. 1½d. per share, the profit in the second half of the year being 12¾d. per share. Of that 12¾d. the Directors took sixpence. He also complained of the Articles of Association, which he characterised as arbitrary, and of the number of the companies which the Chairman was connected with.

The Chairman : Fortunately they are all successful.

Mr. Jackson held that the Directors and shareholders were partners in a joint concern, the former being the managing partners. Though sympathising a good deal even with the personal remarks of Mr. Guesdon, he held that to Mr. Pender, perhaps more than to any one else, was due the extension of telegraphs all over the world. The cables to Suakim and to the Cape of Good Hope, which were laid at a time of national emergency, reflected the highest credit on the Chairman. When Mr. Guesdon said that the Directors were indifferent to the interests of the shareholders in connection with the war which had been declared, that gentleman seemed to forget that the matter was fairly put before the shareholders, who agreed to go into the war, and they had no right to expect any other result than that which had occurred. He did not think that Mr. Guesdon had dealt fairly with the facts of the position when he argued that the shareholders had a grievance against the Directors—the managing partners of the concern, or the shareholders' servants—because their remuneration represented the present large proportion to the net results. He hoped that Mr. Guesdon would withdraw that part of his remarks as being unjust and uncalled for. He agreed with Mr. Guesdon that now that telegraphy was subject to such intense competition, some of the expenses should be reduced, especially if the shareholders were to go on without getting a return on their capital. He considered it an unbusiness-like statement of Mr. Guesdon that the market value of the shares, or of the cables, was the intrinsic value ; and the shareholders having decided on war, the Directors were not responsible for the fall in the market value. He confessed he was disappointed at not hearing from the Chairman, after eight months of the contest, any definition of policy to encourage and give heart to the shareholders in the fight, for it was to be remembered that the loss of dividend which the shareholders were now experiencing was a very serious matter to some of them. Personally, he hoped that, if necessary, the fight would be carried on for a twelvemonth, whether there was a penny earned or whether they had to trench on the reserve fund—a fund which he had always supported in a company like theirs. He would like to know what the result would be to the shareholders if they had the present amount of traffic at a shilling rate. If the "pool" companies made any offer he urged them to publish it to the world, and say that they would not go higher for years.

Mr. Guesdon wished to state that he had not said that the present market value of the shares was all that they were worth, but that the cables were not worth their ledger value.

Mr. Jackson : The present competition does not establish intrinsic value. Even with cables cheaper they must be renewed. The Commercial Company may find that out at any moment.

Mr. John Newton said he did not consider it worth while to dispute about the value of the cables. The plain statement of fact must be patent to everyone that the value of the cables in the ledger was about 50 per cent. more than they could be obtained for. He had risen to express his satisfaction with the report, and for the reason that the Directors had paid a dividend out of the reserve fund. He thought it a misfortune of the cable companies that at the present moment the Anglo-American Company could not do the same. If they could, the victory would be in the hands of the associated companies. The Anglo-American Company, however, in his opinion, was not formed by men of the same capacity as those who had formed the Direct Company, nor did they take the same care in regard to the interests of the shareholders, or they would have protected them from the position which had now arisen. His (Mr. Newton's) argument at the last meeting that the interest on the reserve fund was part of the shareholders' revenue was knocked over on that occasion; but on the present occasion it was admitted, and he hoped the same view would be taken in the future on this matter. The amount taken from the reserve fund in order to continue to pay something to the shareholders was, after all, only £2,658, because the reserve fund should be debited with the cost of the repairs. He believed that if the Directors announced that they intended to make use of the reserve fund for the necessities of the shareholders it would give strength to the shareholders and also to the market value of the shares. He considered that Mr. Guesdon was quite in order in the remarks he had made, for in the struggle now going on the Directors must be guided by common sense, and be sufferers with the shareholders. In his (Mr. Newton's) opinion it was the large fees paid to Directors that induced the establishment of companies As to the new Atlantic Cable Company to which the Chairman had referred, some of the Directors were of not such high standing as might be considered by some persons, but were, in reality, simply "guinea-pigs."

The Chairman, in reply, said he thought they had learned by now that every man had his hobby. He did not object to that at all, but he did think that the hobby ought to be ridden in moderation. Mr. Guesdon had made himself very prominent. He understood that that gentleman had retired from business, and was very fond of airing his eloquence at public meetings generally, as he had done that day. Mr. Guesdon had conceived the idea that it was his mission to reform public companies in London, and with that idea he went to their meetings—to sacrifice his time in exposing what he regarded as bad management. He had listened to Mr. Guesdon's speech throughout, and with the exception of one or two points no practical man in the Company could have come to any other conclusion than this — that Mr. Guesdon's remarks, made at a time when they were fighting their opponents, were much more calculated to damage their property than to benefit it. That was the point he wished to make, and having made it, it was not his intention to go through Mr. Guesdon's various rambling remarks. The impression on his mind was not that Mr. Guesdon had come there to benefit the Company, but for playing into the hands of those whom the Company were opposing. Mr. Jackson had said that he (the Chairman) had not held out any hope to the shareholders ; but the hope he had held out was that Mr. Mackay, as a straightforward business man, must have realised by this time that he was not getting the return on the capital which he had put into the Atlantic that he was entitled to, and which probably he might have got had he entered into the negotiations proposed to him before the companies reduced the tariff to 6d. He (the chairman) had been asked to state what the negotiations were, but in the shareholders' interests he must decline to say one word on that subject. When the tariff question came up again—and he hoped it would not be at any distant time—the Directors would be prepared to deal with it, and in a business way. They had learnt many things from Mr. Newton, who was a very good accountant, and they had adopted many of the suggestions of that gentleman ; nor was he (the Chairman) ashamed to acknowledge the fact. Mr. Newton had brought before them that day the question of the reserve fund, but what he had said was not quite correct. They were not taking from the reserve fund the amount required in order to pay the dividend, but from the interest which accrued on the investments forming the reserve fund. That was a question which he and Mr. Newton had fought over on former occasions.

Mr. Newton maintained that only £2,650 was taken because there was the amount which was required to meet the costs of the repairs.

The Chairman, continuing, said that the cost of the repairs came from the reserve fund proper—the reserve fund which was put aside. He thought, however, that the question might be one of account ; and he did not think that Mr. Newton or himself was likely to differ on how the matter should be dealt with.

Mr. Newton asked whether it was intended to continue to use the reserve fund in the same way.

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The CHAIRMAN requested the meeting not to ask him to commit himself or the Directors to anything that might hamper them in the future. Mr. Newton had said very truly that the Articles of Association of the Anglo-American Company prevented that company from doing what they might have done on such occasions, as the Direct Company had done that day, in drawing on the reserve fund. He asked that the hands of the Board of the Direct Company might not be similarly tied, though they were quite open to suggestions, or to be corrected in any course they might take which might not be in perfect harmony with the shareholders' views. Great caution and energy were required to carry on such a fight as that which they were now engaged in; and if the shareholders could not trust the Directors it would be better to turn them away altogether. Mr. Guesdon had spoken about his (the Chairman's) connection with fifteen different companies. A great number of them, however, were telegraph companies, and it had been necessary to establish those companies in sections. Within the period in which they had been working—twenty years—they could not have got invested £35,000,000 in submarine telegraphy had the enterprise been started as one company. The progress of submarine telegraphy had been in great measure due to the fact of there having been only one or two heads to direct it. If there had been different Boards, with jealousies to pull them one against the other, the result generally would have been what they saw in some of the companies—no dividend. The companies Mr. Guesdon taunted him with presiding over, he (the Chairman) took credit for having carried on in such a way that they had made great progress, and while being beneficial to the public had paid dividends to the shareholders. The existing Atlantic competition was probably one of those things which might be regarded as exceptional, but notwithstanding, even now they saw that his colleagues and himself were struggling to give the shareholders something while the fight was going on. Mr. Jackson had asked, Cannot you say when it is going to end? Suppose he (the Chairman) said, We are tired of this, and it will end in a very short time? Was that the way to fight a battle? He thought the shareholders would say No. The people they were opposing would then say, Let us wait, they are getting tired of it. He (the Chairman) said quite the reverse. They had laid down a policy. That policy had been approved by the shareholders, and unless the latter shirked the position it was not the intention of the Board for one moment to give in. They would go on as at present, and they would win. He had got rather warm, but he hoped the shareholders would not blame him, for he was warm in their cause. As long as he was their servant, and their leader, they might depend on it he would protect their interests (applause). He put the motion, and expressed his satisfaction at it being carried unanimously, because it would encourage the Directors, and be rather disappointing to those who were watching with much interest the proceedings at the meeting of the Company that day.

Mr. JACKSON said that the present state of affairs taxed the patience of the shareholders very much, and at such a time the Chairman must expect a little rough handling. The Chairman had, however, discussed the position very fairly, and he (Mr. Jackson) hoped that the next meeting would be somewhat more satisfactory. He then proposed a vote of thanks to the Chairman for his able conduct in presiding, and to the Directors for their management of the Company's business during the past half-year.

Mr. HINTON seconded the motion, which was carried unanimously.

The CHAIRMAN, in acknowledging the compliment, said that they might depend upon it that the Directors would endeavour to command the confidence of the shareholders, and if at any time the Board differed from the shareholders they would give very good reasons for the position they might take up.

The proceedings then terminated.

The New Telephone Company.

An extraordinary general meeting of this Company was held on Saturday, at the offices of the Company, 4, Great Winchester-street, E.C., Lord Thurlow presiding.

The CHAIRMAN stated that the meeting was convened to pass resolutions authorising the Directors to proceed at once with the formation of various district and provincial sub-companies. The moment was most propitious for what they had in view. He thought it was not too much to say that the existing telephone arrangements of London were a disgrace to the country, especially when compared with foreign countries such as the United States, Germany, or even a small country like Sweden. He could mention one town in South America, with nearly as many subscribers as there were in London, where, indeed, the telephone had not yet reached the public. The time would come when healthy competition would bring the telephone into every shop and office in London. Various schemes had received their consideration—the issue of further share capital, the establishment of branch companies, and the reconstruction of the old company. This last was the course they had eventually decided to follow. Their Company as it stood was only a syndicate. They proposed, therefore, to form a strong Company with a suitable capital to take over the assets and liabilities of the old company. They could establish exchanges at a rental of £10 and realise handsome profits. They would not be overweighted with dead capital, as they had paid nothing for their patents, and they would not have to begin by renewing an obsolete and inefficient plant, but would at once step into the latest scientific and mechanical improvements. He would reserve details for the confirmatory general meeting which would have to be held, and which would be called with the least possible delay, but he desired to mention that they were in communication and negotiation with strong representative people in Glasgow, Dundee, Edinburgh, Kirkcaldy, Liverpool, Manchester, Preston, Bristol, Cardiff, Leamington, Birmingham, Bedford, Oxford, Cambridge, Somerset, and very many more places. There was one branch of the business entirly neglected at present which they would largely take up—the intercommunication of towns with one another. He concluded by moving the formal resolution of which notice had been given.

Sir JAMES M'GAREL-HOGG seconded the resolution, which, after questions by Colonel Steuart, Colonel de Cetto, and other shareholders had been answered by the Chairman, was passed unanimously.

Cuba Submarine Telegraph Company (Limited).

Report of the Directors for the half year ended 31st December last, to be presented at the thirty-first ordinary general meeting of the shareholders at the Company's Offices, 61, Old Broad-street, E.C., on Wednesday, the 2nd February, at 1 o'clock:—

From the balance-sheet and accounts it will be seen that the gross receipts (including the balance brought from last account) amount to £17,845. 10s., and the gross expenditure (including the half of the annual payment on account of the 1881 cable, and the amount expended on cable repairs) to £6,098. 15s. 6d., leaving a sum of £11,746. 14s. 6d. to the credit of revenue account. Of this the sum of £1,795. 15s. 3d. has been added to the reserve fund, increasing that fund to £66,500. The dividend on the preference shares will absorb £3,000, and leave £6,950. 19s. 3d., out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income-tax, the balance, £550. 19s. 3d., being carried forward to the current half year's account. The cables have continued in good working order, excepting one of the Santiago Harbour lengths, which has been repaired by Mr. Keith, the Company's engineer. The usual comparative statement of traffic is submitted with the Directors' report.

India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

Subject to audit, this Company's accounts to 31st December last show the following result:—

Brought forward from 1885	£40,947
Net profit for 1886	59,400
	100,347
Less interim dividend paid in July, 1886, 5 per cent. ...	20,800
	£79,547

The directors have resolved to recommend a dividend of 10 per cent. (making 15 per cent. for 1886), and to carry forward £37,947.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JAN. 26.		BUSINESS DONE WEEK ENDING JAN. 26. Highest.	Lowest.
Anglo-American	32½,	33½	33½	—
Do. Preferred	53⅝,	54½	56⅛	53½
Do. Deferred	11⅝,	12⅛	11⅞	11½
Brazilian Submarine	10¾,	11	10⅞	10 13-16
Cuba	11¼,	11¾	11¾	—
Do. Preference	18,	19	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	7⅞,	8⅛	8⅛	8
Eastern Telegraph	10¼,	10⅜	10½	10 3-16
Do. 6 per Cent. Preference	13,	14	13 7-16	13⅝
Do. 5 per Cent. Debentures, 1899	107,	110	—	—
Eastern Extension	10⅜,	10⅞	10⅞	10½
German Union	8¾,	9¼	—	—
Globe Telegraph and Trust	4⅝,	4⅞	5⅛	4¾
Do. Preference	12,	12¼	12⅝	12
Great Northern	13⅛,	13⅜	13⅛	—
Indo-European	34,	35	—	—
Reuter's	6¼,	7¼	—	—
Submarine	190,	200	—	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	8½,	9	8 13-16	8⅝
Western Brazilian	7½,	7¾	7 13-16	7⅝
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	¼,	⅜	—	—
United Telephone	12½,	12¾	12⅞	12⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2,	2½	2½	—
Do. (fully paid)	3¾,	4¼	—	—
Swan	1⅜,	1⅝	1 9-16	—
Maxim Weston	3-16,	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	39	40	40	39½
India Rubber, Gutta Percha, and Telegraph Works	23½	24½	24¾	24½

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NOTES.

CHINESE TELEGRAPHS.—During the year 1886 thirty-six telegraph offices were opened in China.

ATLANTIC CABLE INTERRUPTED.—The cable of the French Atlantic Cable Company is interrupted.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 28th ult. amounted to £3,961.

THE EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for January 1887 amounted to £53,435, and to £57,317 in the corresponding period of 1886.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for January amounted to £1,888, against £1,700 in the corresponding period of last year.

FATAL ACCIDENT TO A LINEMAN.—We regret to note that at Bournemouth, on Monday last, a telephone lineman, while at work on the roof of a house, fell over the parapet and was killed.

PERSONAL.—We understand that D. Zetzsche, who has for some years undertaken the editorship of the *Elektro-Technische Zeitschrift*, is about to resign his connection with this important journal.

ELECTRIC LIGHTING ACT AMENDMENT BILL.—In the House of Lords, on Monday last, a Bill to amend the Electric Lighting Act of 1882 was brought in by Lord Thurlow, and read a first time.

ELECTRICAL HOIST.—Messrs. Drake and Gorham are engaged in fitting up an electric hoist, which will be worked in conjunction with the apparatus they lately fixed for the lighting of one of the London banks.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of January amounted to £39,331, and to £39,699 in the corresponding period of 1886.

THE NATIONAL FAWCETT MEMORIAL.—The total sum contributed to the Fawcett Memorial amounted to £4,213. 3s. 8d., of which £1,085. 12s. 6d. (or one quarter of the whole amount) came from *employés* of the Post Office.

"JOSEPH HENRY AND THE MAGNETIC TELEGRAPH."—Messrs. Scribner, of New York, send us a copy of a little book under the above title, being an address delivered at Princeton College by Dr. Edward N. Dickenson.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended January 28 were £3,256, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE PROPOSED ELECTRIC TRAMWAY AT BRAY.—On the 27th ult. a Board of Trade inquiry was held at Bray with reference to a proposed electric tramway of which some mention has previously been made in our columns. The line will be less than one mile in length.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended the 31st January are £2,780, as compared with £2,839 in the corresponding period of 1886. The October receipts, estimated at £3,907, realised £3,916.

THE PARIS-BRUSSELS TELEPHONE.—On Wednesday direct telephonic communication was established between the Elysée and the Palace of Laeken, enabling M. Grévy to hold a conversation with the King of the Belgians. The Queen afterwards listened to rehearsal of the opera at Paris.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS. The next meeting of this society will be held at the Institution of Civil Engineers, on Thursday, February 10th, at 8 p.m., when the adjourned discussion upon Prof. Silvanus Thompson's paper on "Telephonic Investigations" will be proceeded with.

DECORATION.—Mr. Dunn, who has on several occasions acted as special agent in China to the Eastern Extension Telegraph Company, has recently been awarded the Order of the Imperial Dragon of the first class of the third division by the Chinese Government in recognition of his services during recent negotiations with the Vatican.

THE VOLK ELECTRIC RAILWAY TESTIMONIAL.—We would call the attention of those of our readers who have been interested in the recent action for damages against Mr. Magnus Volk to the advertisement which appears in another column with regard to the testimonial fund which is being raised by some of Mr. Volk's friends at Brighton.

KNOTTINGLEY.—At Messrs. Croysdale and Sons' flour mill, near Knottingley, Mr. Wilson Hartnell has just completed an installation comprising one compound self-regulating dynamo and 63 16 candle-power Edison-Swan lamps. The dynamo is driven from the line shaft on the bottom floor, power being supplied by a large water wheel, which drives the whole mill.

LIGHTING OF THE PLACE DU CARROUSEL, PARIS.—At Paris the Municipal Council have refused to renew the credit of 35,000 francs (say £1,400) which was granted last year for the maintenance of the electric light in the Place du Carrousel. This installation, says a French contemporary, had been carried out in a very defective manner, and from the first gave very little satisfaction. We believe that it consisted of Jablachkoff lamps.

THE GOVERNMENT AND THE TELEPHONE COMPANIES.—In the House of Commons, Mr. Hugh Watt has given notice of his intention to ask the Postmaster-General the following question :—"What progress has been made in any negotiations which may be pending between the Government and the telephone companies with a view to the acquisition and extension of the present lines, and the removal underground of all existing overhead wires."

THE TELEPHONE BRIDGE.—Referring to a recent note, in which we mentioned that a portable testing bridge, with a telephone instead of a galvanometer, had been introduced by Messrs. Siemens and Halske, of Berlin, we are now informed that Messrs. Siemens Brothers and Co., of London, have introduced the same feature in their own portable testing apparatus. The original form of this apparatus was described and illustrated in our issue of 30th August, 1884.

SILICIUM BRONZE WIRE.—We hear very good accounts of the behaviour of this wire during the recent severe weather. Of course the chief thing necessary in the construction of overhead wires is to avoid long spans wherever possible. At Prague, over the River Moldau, there is a span of 430 yards crossed by seventeen silicium bronze wires. This line was erected three years ago, and the first breakage occurred during the severe storms at the close of December, when seven wires gave way.

THE BRUSSELS TELEPHONE EXHIBITION.—We hope shortly to be able to place before our readers a full description of the

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Exhibition of Telephony now open in Brussels. In the meantime we are pleased to observe a unanimous expression of opinion in the Belgian journals (and which is also confirmed by private information in our own possession), that the show of the Consolidated Telephone Company, of this country, is *facile princeps* of the Exhibition; next to this, apparently, comes the Telephone Construction Company, of Antwerp.

PROF. AYRTON'S COURSE OF LECTURES ON DYNAMO TESTING.—We would remind our readers of the commencement of the course of lectures, with practical illustrations, on the testing of dynamos, which are to be given by Prof. Ayrton at the City and Guilds Institute, South Kensington, on Wednesday and Friday afternoons, during February and March. The first lecture will be given on Friday next at 5 p.m. The full syllabus will be found in our issue of December 31st. In the case of teachers, or of several students from one firm, the fee will be reduced to 15s.

THE PARIS OPERA LIGHTING.—During the last few evenings the Paris Opera has once more been lighted by gas. The circumstance is not, however, capable of being made the subject of any great degree of exhilaration in gas-lighting circles, inasmuch as the interruption arises from the fact that the electric lighting installation is about to receive extensive additions. The space available for the machinery being very limited, it has not been found practicable to place an additional machine, hence the dynamos previously in use have been removed to make way for machines of greater capacity.

BELTING—Two new types of belting have recently been introduced, and each is probably worth the attention of electrical engineers. Messrs. Thomas Fleming, Son and Co., of Halifax, make a "perforated" belting especially for running at high speeds. Holes are bored in the leather at distances of 1 inch apart, so as to permit the escape of the layer of air between the belt and the pulley. It is stated that such a belt will run much slacker than the ordinary types. The other belt is the invention of M. Adie, of Paris, and consists of a thin steel band made undulating in the direction of its length. This belt has been tried with considerable success; it is stated that it has very little tendency to slip.

THE NATIONAL TELEPHONE COMPANY.—This company send us the latest issue of their list of subscribers for the West Cumberland district, from which we gather that since August last the number of connections has increased by fully 100 per cent. Two new exchanges have been opened during the last two months, one at Parton and the other at Cleator Moor. The directors of the company recommend an interim dividend for the six months ended December 31 at the rate of 6 per cent. per annum on the First and Second Preference shares, and at the rate of 3½ per cent. (as against 3 per cent. for the corresponding period last year) on the Ordinary shares, £727 being carried forward. The unaccrued revenue carried forward to the credit of next account amounts to £38,722, as against £34,058 in 1885.

LECTURE ON THE TELEPHONE.—Mr. F. F. Bennett, the National Telephone Company's local manager in West Cumberland, delivered a lecture at the Scientific Institution, Maryport, on January 23rd, on the telephone and its applications. Mr. Alfred Hine occupied the chair, and there was a crowded audience. The subject was profusely illustrated by apparatus and experiments, and by means of telephones attached to long flexible wires, which could be passed from hand to hand, the audience was enabled to hear music and conversation originating in several of the neighbouring towns. A telephonic concert on perhaps an unprecedented scale was in this way enjoyed. Miss Richardson at Cleator Moor (seventeen miles distant) sang several songs, which were accompanied on the piano by Miss Burnett at Workington (six miles). Votes of thanks to the lecturer and his widely-diffused assistants were carried by acclamation.

"SAFETY CIRCUIT" FOR INCANDESCENT LAMPS. — Mr. Edwin Greenfield, of New York, has recently introduced a plan for wiring circuits in cases where the insulation is liable to be attacked by moisture. Although somewhat expensive to carry out, this method appears to be capable of affording a very perfect protection against dangerous leakage. The idea is very simple. An uninsulated wire is carried around the whole circuit, placed everywhere between the positive and negative leads. One end of this wire remains free, while the other is connected to one of the main leads at a point near the terminal of the machine, but beyond the principal safety fuse. Before its connection with the main this additional circuit is made to contain a magnet coil, so arranged that when the leakage current exceeds a certain amount the armature is pulled down and short circuits the mains, causing the immediate action of the safety fuse. The arrangement will scarcely commend itself for general purposes, but in exceptional cases it may prove useful.

THE BELL PATENTS IN THE STATES.—To attempt to follow all the intricacies of the apparently interminable proceedings in the United States Courts in connection with the attack and defence of the Bell telephone patents, would be a most wearisome and unprofitable proceeding. The American journals continue, however, to devote a good deal of attention to the affair, and it appears that matters will soon be brought to a crisis. If any of our readers are anxious to become acquainted with the points upon which the opponents of the patents now lay the greatest stress, we commend them to an article in the *New York Times* of the 20th January. This article is headed, "A Bombshell for Bell; Startling Charges in the Telephone Cases," and proceeds to give long extracts from the brief which has been filed by the "People's Telephone Company," wherein fraudulent proceedings are attributed to the agents who acted on behalf of Prof. Bell. On these matters we, of course, express no opinion whatever, and can only hope that the whole affair may be brought to some definite issue at the earliest possible date.

CABLE REPAIRS—QUICK WORK.—Captain J. F. Farrier of ss. "Duchess of Marlborough," writes us from Grenada (West India) on the 5th January, giving an account of some quick work recently carried out by this ship in the repair of the cable of the West India and Panama Telegraph Company. Mr. A. C. O'Bryen is the electrician in charge of these operations. Captain Farrier says: "(1) We left St. Vincent 31st December at midnight to repair a break in the St. Vincent-Grenada, 37 knots from the former station. January 1st, 1887, 8 a.m., commenced work on ground; 10 a.m., north end buoyed; 11:15 a.m., south end on board; 6 p.m., line through after putting in 3½ knots of new cable in a depth varying between 250 and 300 fathoms. (2) Removal of fault (which only interfered with working) in the Grenada and Trinidad cable, about 8 knots from this island, was even quicker than the above. Times as follows: January 4th, 1887, 7 a.m., weighed anchor from Grenada; 8:30 a.m., cable on board; 11 a.m., fault removed; 4 p.m., line through with very much improved signals, after laying in ¾ of new cable; 5:30 p.m., anchored in Grenada Harbour."

THE INDIAN AND COLONIAL EXHIBITION MACHINERY SALE. The sale of electric lighting machinery and apparatus, held by

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Messrs. Wheatley Kirk, Price, and Goulty, at South Kensington on January 26th and 27th, was attended by a large and influential company from all parts of the kingdom. Among the principal buyers were the Duke of Marlborough, the Marquis of Salisbury, the Marquis of Bute, Lord Edward Churchill, Lord St. Oswald, &c. We are informed that the prices realised were, on the whole, considered very satisfactory. The cable, of which there were many miles and which had of course all been used, some of it since the commencement of the series of Exhibitions, averaged £50 per ton, and in some instances more than double this. Of the several thousand lamps, all of which had been used, the prices ranged from 1s. to 2s. 9d. The semi-portable boilers average £180 a piece. The triplex engines, by Goodfellow and Matthews, were not in favour, and there was no competition for them. A "Paxman" horizontal high-pressure engine, indicating 300 horse-power, fetched £320, a price which certainly cannot be considered excessive. The only large dynamo left in the sale was an Elwell-Parker 40-unit machine, which fetched £240. About 100 B.T.K. secondary cells were sold for £52.

Proposed International Congress of Science and Industry.—In the year 1888 it is proposed to hold at Brussels an International Congress of Science and Industry. Prizes to the amount of 500,000 francs, consisting of gold, silver, and bronze medals, as well as diplomas of honourable distinction and "diplômes commemoratif," will be awarded to the authors of the best papers on various stated subjects. The project appears to be as yet in a somewhat elementary stage, and in the present condition of political affairs it would be rash to prophecy the success of an enterprise of this nature for the year 1888. The idea is, however, undoubtedly a good one; it will afford a welcome change from the somewhat wearisome round of international exhibitions, and seems to us to be well calculated to render effective service to the progress of applied science. The following questions are entered on the provisional programme for discussion in the electrical section: Motors and Dynamos; Accumulators and Transformers; Lightning Conductors and Protectors; Telegraphs and Telephones; Wires and Cables; The Transmission of Force; Arc and Incandescent Lamps; Electro-Chemistry and Electro-Plating. In the commercial section special attention will be paid to the question of export and import duties.

Calcutta.—The incandescent lamp made its first appearance in Calcutta on Christmas Eve, when the "Hall of All Nations" and the Great Eastern Hotel were illuminated. The installation consisted of 150 lamps supplied by a Ferranti machine, running at 1,000 revolutions, and yielding 112 amperes at 77 volts. A small Gramme is employed for exciting the field-magnets, and the machines are driven by an eight horse-power portable engine. The lamps in the hall were supplied with opaline shades of various tints, and the effect seems to have aroused the enthusiasm of the visitors, to whom the term "electric light" had in most cases hitherto signified the arc light only. The contractors for the installation were Messrs. Walsh, Levett and Co., and we shall wish them every success in the vast field of enterprise which lies before the electric light in our Indian Empire. We may, however, suggest that they would do well to avail themselves of later and more efficient methods than the one which they seem to have adopted in the present case. The Ferranti was at the time of its introduction a very fair specimen of the electrical engineering of the period, and still, perhaps, has a field before it for certain special purposes. But for working directly upon the lamp circuit there are half a dozen machines of later design which may be employed with greater advantage.

The "Sucking" Telegraph.—One of the latest Yankee "ideas" is the "Sucking" telegraph receiver. This instrument does not derive its name from that of the inventor, but from the present participle of the verb "to suck." It has long been known that telegraph operators who work continuously upon sounder circuits, are, at times, liable to suffer from the strain upon the auditory nerve. As a measure of relief the "touch-sounder," by which messages are received through the tickling of the operator's finger, has already been brought into use in the States; but even this arrangement is found to be attended with some degree of inconvenience after a prolonged spell of work. Now, however, a philanthropist inventor has come forward with an idea which promises finally to place the poor plodding telegraph operator in the enviable position of being able to get through his day's work with only the most inappreciable amount of mental or physical fatigue. He has discovered that the nerves of the tongue and palate are able to accomplish the greatest amount of work with the least possible strain. He therefore modifies the arrangements of the "touch-sounder" in such a way that the indicator is placed in the mouth instead of in the hand—hence the name "sucking telegraph." If the authorities of our postal telegraphs should see fit to adopt this instrument, the interior of the Central Telegraph Office is likely in future to present a decidedly palatable spectacle.

The Eastern Telegraph Company in Spain.—We hear from Madrid that the Eastern Telegraph Company have made a request to the Spanish Government for permission to lay a new land line direct from Bilbao in the north to Cartagena in the south, connecting in the latter part with a cable to Gibraltar and Malta. The motive for this request appears to be to obtain another route through Spain to the East, which may be free from the possible disadvantages which, under certain circumstances, might arise in connection with the present French route *viâ* Havre and Marseilles. The general rate for telegrams in Spain is 10 centimos per word, but the rate offered by the Eastern Telegraph Company for through traffic is 8 centimos per word, which is the present tariff for internal messages, and is considered sufficient, seeing that there would be no expense connected with the transmission, collection, and distribution of messages. For some reason or other, however, the Spanish authorities have not yet seen their way to grant the concession, and paragraphs have appeared in the local press pointing out the advantages offered by the proposal, one of the most important of which is that a direct telegraphic communication would thereby be obtained with the Philippine Isles. The company, it is stated, has offered to lay the wire, and to recoup itself the expense out of the payment it would have to make to the Government. The Minister of the Interior (Señor Leony Castillo) is therefore urged to grant the concession asked for.

Government Telegraphs in Canada.—The following paragraph shows the present position of the Canadian telegraphs:—The recent trouble between the Great North Western Telegraph Company and the Montreal Telegraph Company has revived the agitation in favour of the Dominion Government assuming control of the whole telegraph service of Canada. The Government only owns and operates such lines as have been built in furtherance of the public service. These lines have mostly been constructed in connection with the signal service along the Gulf of St. Lawrence, the Maritime provinces, and British Columbia, and also for the advancement of settlement in the sparsely settled districts of the North West territories.

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The last official return of Government lines in operation places the total length at 3,144 miles. In 1885 the cost of maintaining and working them was $70,977, on account of which $46,419 was received as revenue, leaving a deficit of $24,558. According to the last published estimate, there were 24,100 miles of public lines in Canada, with 2,415 offices, and since that date the Canadian Pacific Railway Company have added several thousand miles to the telegraphic system of the Dominion, the figures relative to which have not yet been made public. As an evidence of the largely increased telegraphic accommodation in Canada since confederation twenty years ago, it may be said that on December 31st, 1867, the total length of all telegraph lines was 7,227 miles, with only 497 offices, or one office to every 7,042 of population. On June 30th, 1875, there were 24,100 miles of line, 2,415 offices, or one office to every 1,944 of the population.

BRADFORD.—With reference to the proposal now before the town council of Bradford, relating to the central lighting scheme, to which we referred in our issue of the 21st ult., one of the local journals makes the following remarks:—"The Bradford Corporation is taking a step which, whatever comes of it, sufficiently testifies to its desire to keep the trading interests abreast of any improved facilities for artificial illumination. Already holding the supply of gas to the borough, the Corporation is now prepared to undertake the supply of the electric light should it be the wish of the ratepayers that this should be the case, and with this view means are now being taken to elicit an opinion on the subject. As will be generally known, parliamentary powers to supply electric lighting to the town were obtained by the Corporation in 1883, but nothing has yet been done towards that object, for the sufficient reason that no general desire has been expressed on the part of probable consumers in favour of this mode of illumination over that of gas; while on the part of the corporate body, it would have been imprudent, to say the least, had costly plant been put down without some reasonable prospect of a return. Nevertheless, private electrical firms are already in the field, and further procrastination in testing public feeling on the subject would have been equally reprehensible on the part of the Corporation. Accordingly, circulars have been sent to business firms within a radius of a quarter of a mile of the Exchange, inviting replies to the query whether such firms agree to take the electric lighting if provided by the Corporation for a fixed period, say three years, at a reasonable price. Should the replies received be of a character to justify the Corporation in proceeding, the work might be undertaken as a corporate work, as gas is being at present supplied, or arrangements might be made under contract with existing electrical furnishing companies; but in any case it is deemed desirable that the scheme should be in the hands of the local authorities, and that the ratepayers and consumers should receive any benefit accruing from such an arrangement. At present it would be premature to hazard any opinion on the result of the *plébiscite*, but the lapse of a few days will suffice to put us in possession of the required information. Meanwhile the corporate authority has done its part in taking the initiatory step already indicated."

M. HOSPITALIER'S EXPERIENCE OF LIGHTING BY BATTERIES. Some three years ago M. Hospitalier fitted up at his own residence a bichromate battery which was employed continuously in charging some secondary cells, and from the latter he obtained current for a small installation of glow lamps. Several modifications and improvements have from time to time been introduced, and M. Hospitalier now expresses himself as being well pleased with the results obtained, although the total expense for maintenance and depreciation does not come out less than 2d. per 10 candle-power lamp per hour. The arrangement adopted consists of a series of 8 double-fluid bichromate cells, through which an automatic flow of liquid is maintained by means of a system of siphons very similar to that devised by M. Baudet. The inner cells contain the zinc in the form of a cylinder 15mm. in diameter; surrounding this is a circular plate of carbon. The number of secondary cells employed is 7, and to supply them with a charge of 15 ampere-turns requires in the primary battery the use of 3 litres (5¼ pints) of bichromate solution, and the same quantity of dilute sulphuric acid. The total consumption and cost of materials was carefully noted during a period of two months, with the following results (which, however, we will put into English measure):—48·5lb. of bichromate of soda at 3¾d. per lb. costs 15s.; 165lb. of common sulphuric acid at 0·65d. per lb. costs 9s. 4d.; 48·5lb. of zinc at 3·4d. per lb. costs 13s. 9d.; and 10½oz. of mercury at 2s. 3d. per lb. costs 1s. 8d.; total for the two months' working £1. 19s. 9d., or, say, £1 per month. For this actual outlay M. Hospitalier obtains a discharge of 15 ampere-hours under an E.M.F. of 12 to 13 volts. His 10 candle-power lamps, therefore, take about two amperes, and one such lamp can be lit for seven hours daily. But there are actually placed in different parts of the house *nine* separate lamps of various powers, requiring from one to four amperes each. The above figures represent a cost per lamp-hour (of 10 candle-power) of 1·4d., which, however, will be increased, M. Hospitalier thinks, to about 2d. when the depreciation of the lamps and batteries is included. The manipulation of the batteries by the domestic servants is said not to be attended with any inconvenience when once they have become accustomed to the work. We are very pleased to find that M. Hospitalier has succeeded in obtaining results which satisfy his own personal requirements. We fear, however, that the figures above given can scarcely be considered to afford any great encouragement for the introduction of primary battery lighting from a commercial point of view.

MAGNETIC HEATING.—It is not a little singular that the question whether or not the reversal of the magnetism of an iron core is accompanied by any heating effect other than that due to the eddy currents has never yet been set at rest. It is somewhat difficult to imagine that the molecular motions of the iron, whatever may be their intrinsic character, can, in reality, take place with such perfect freedom that all degradation of energy is entirely avoided. Indeed, it has already been pointed out that the fact that the linear dimensions of an iron bar vary with its magnetic condition proves that in the case of a ring undergoing magnetic reversals a minute deformation of shape will tend to occur. This observation is, we believe, originally due to Mr. F. H. Nalder. But if from this or any other cause magnetic heating exists, it is certain that its amount is trivial in comparison with that due to eddy currents. We recently witnessed some experiments in which a very rapidly alternating current was passed through two coils placed one upon either end of a bundle of very fine iron wires about 3ft. in length. Under these conditions the iron immediately adjacent to the coils soon became uncomfortably hot to the touch, while in the middle its temperature had not apparently increased. The experiments were not intended to bear upon this particular point, but the observation certainly tends to confirm the idea that by far the greater part of the heating effect upon iron core is due merely to Foucault currents. It appears to us that the question of separating these two effects might be attacked in the following way. Let a number of bundles of soft iron wire be prepared, all of the same

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weight and the same length, and as nearly as possible of the same shape and diameter; but let each separate bundle consist of wire of different diameter to the others, so that the series begins with the finest wire procurable and ends with a single piece of rod. Let the wires in the bundles be separately varnished or otherwise electrically insulated from one another. If now arrangements be made to subject each of these cores to rapid reversals of magnetic polarity, it is known that that part of the heating effect due solely to Foucault currents will diminish as the number of sub-divisions of the core increases. If then a curve be plotted whose co-ordinates are represented by the rise of temperature and by the number of sub-divisions of the core respectively, it should be possible, by taking a sufficient number of observations, to determine the nature of the curve in the neighbourhood of the point where the core would be divided into an infinite number of wires of infinitely small sectional area; and from this it would be apparent whether or not any heating effect after the complete dissipation of Foucault currents.

THE INDIAN TELEGRAPH SERVICE.—*Indian Engineering* writes as follows on the annual report of the Indian Telegraph Service:—"It is gratifying to find from a resolution of the Government of India published last week that during the year 1885-86 the progress made by the telegraph department was admirable, as will be apparent by consulting the following figures. The length of lines was increased by 2,123 miles of new lines, making a total of 27,510 miles. The length of wires was increased by 6,507 miles to a total of 81,480 miles, and the number of new offices opened to the public was 176. On the other hand, the number of messages sent from departmental offices only was 2,289,938, showing an increase of 274,841 (above 60 per cent. of these being inland private telegrams), or more than 13 per cent. over the number for the previous year, and the total receipts from the despatch of telegrams amounted to Rs.39,61,052, an increase over the previous year of Rs.4,63,025. This sudden large augmentation of message revenue was in part due to the events on the North-West frontier at the beginning of the year, and the military operations in Burmah during its close; still, the receipts from the inland private traffic were satisfactory, being Rs.16,38,000, or Rs.1,33,000 more than in the previous year. The falling off in the receipts from the foreign private telegrams is very properly attributed to the steady decline in the value of silver. Comparing these figures with those for 1883-84 we observe that the length of lines has been increased by 17·9 per cent., the number of offices by 27·7 per cent., and the revenue from messages only (excluding those sent from other than departmental offices) has risen by 23 per cent., while the working expenses have also diminished by 3·4 per cent. during the past three years. The initiation of two important reforms—the opening out of offices worked by extra departmental agency in connection with the Post Office, and the system of 'deferred telegrams'—has contributed in no small degree to the effective working of the present system, and to the great relief invariably afforded to the offices and lines. The former constitutes two-thirds of the agency employed, and the latter contributes 63·15 per cent. of the entire traffic, thus marking an era in the development of the department. Since 1881-82 the number of departmental offices has been nearly doubled; the gross revenue has risen from Rs.38,54,212 to Rs.51,10,986 in the year under review; the charges against revenue account have increased from Rs.32,35,644 to Rs.36,18,695 only, and the net revenue from Rs.6,18,568 to Rs.14,92,291. The capital expenditure at the close of 1885-86 was Rs.3,83,16,760, of which about Rs.29½ lacs was expended during the year. With such a large increase of business as we have adverted to above, the workshops were fully employed during the year, and the erection of new buildings gave a great impulse to the endeavours of this department to substitute articles of local manufacture for those hitherto imported."

POST OFFICE TELEGRAPH MECHANICS.—The following remarks upon the status of the telegraph mechanics employed by the Post Office appeared in the *Newcastle Daily Leader* of the 29th ult., and as it seems to us sets forth very convincingly the claims of a highly trained and very deserving class of public servants:—"There is reason to believe that while the upper branches of the Civil Service still enjoy high salaries, much in excess of similar posts in foreign countries, the officers of the lower branches, where there has been the greatest development in recent years, are often underpaid, and even unrecognised as Government *employés*. Owing to the necessity of keeping down the estimates, the fair claims of the humbler departments of the service have been ignored by officials, when a readjustment of the scale of salaries might have secured a more just distribution of the nation's payments among its servants without excessive increase in the sum total. The Royal Commission on Civil Establishment has lately issued inquiries to the various departments of the service, asking for a statement of complaints or requests. An opportunity has thus been afforded to the mechanics employed in the engineering branch of the Post Office Telegraph Department in provincial towns of making known what seem to be fair grounds of grievance. The manufacture and repair of the delicate instruments and complicated machinery of the telegraph are carried on in the Post Office workshops of the various central towns in each telegraph district, such as Newcastle, Leeds, Edinburgh, Dublin, Bristol, and others. For this important work it is necessary to employ highly-skilled mechanics and artisans, and these have usually been drawn from the ranks of watchmakers and opticians. The greater number of these machanics, however, are not in the technical sense of the service 'established,' and consequently do not share in the privileges enjoyed by a few of their fellows and the *employés* of the Post Office in other departments. Their wages are low, and their working hours long. They get only a week's holiday instead of three; cannot look forward to a pension after long service; and often see the head posts of their department filled from other sources. It is obvious that the satisfactory working of the telegraph system depends upon the efficiency of the instruments used, and yet the *employés* who are responsible for their good order are not accorded the same treatment as those of the despatch and commercial branches. A telegraph clerk is allowed a sum of 6d. an hour for travelling expenses. A mechanic, whose employment necessarily requires a greater outlay, is only allowed 1d. per hour. A man who has proved his ability in the central workshop of a district and has gained a thorough experience in the testing and management of telegraphic apparatus—and possessing, as many of the mechanics do, not only a practical but a theoretical knowledge of electricity—should have a fair chance of promotion to inspectorships, which are at present generally denied to this department. The specialisation of this branch of the Post Office is becoming increasingly necessary, as the science of telegraphy is rapidly developing. Transmitters and multiplex machines are almost daily receiving improvements, while the new era of cheap messages has created a great increase of apparatus. It is for the public interest that the Government should maintain the highest efficiency in the mechanical department, and secure by adequate remuneration and inducements the services of the most intelligent and skilful artisans available."

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ELEMENTARY ELECTRICITY AND MAGNETISM.—II.

(Concluded from page 255.)

When a separate armature is employed to excite the field-magnets, the current sent through the external circuit by the other armature may be continuous, and always in the same direction, or it may be alternating. In most cases in which machines are employed for the production of alernating currents, the field-magnets are excited by separate exciters of the continuous current class, and the machine with its exciters must be regarded as *one* dynamo, inasmuch as the machine itself is incapable of converting mechanical into electrical energy. The Ferranti-Thomson and the Gordon machine belong to this class. Their field-magnets are excited by small Bürgin or Siemens machines, while the large machines themselves simply transmit alternating currents to the external circuits. In the Gordon machine the coils in which the currents are induced are furnished with iron cores so shaped as to greatly diminish the loss of power due to currents induced in the cores themselves. These coils, instead of forming portions of a revolving armature, are fixed to two circular cast-iron plates forming the framework of the machine, and between the two sets of fixed coils the field-magnets themselves revolve, being attached to a massive disc made of boiler plates rolled together, so as to give a thickness of several inches at the centre. By this arrangement, the coils which furnish the current to the external circuit can be permanently connected with the main leads without the intervention of any sliding contacts, so that there is no risk of sparking in the main circuits in which a current of several thousand amperes may be flowing, and it is only the current employed to excite the magnets that crosses a sliding contact, and this current is only about 40 amperes.

The Ferranti machine belongs to the class in which there is no iron in the armature. The field-magnets are arranged opposite to one another on two discs so that unlike poles of opposite magnets may be at a distance of about an inch from one another. Between the poles, the copper ribbon forming the armature revolves, and the current in the ribbon is reversed every time any section of the armature passes a pair of magnetic poles.

The employment of iron in an armature to come between the poles of the field-magnet not only concentrates the lines of force in the field upon the armature, but enables the same current to produce a much stronger magnet by increasing the magnetic permeability of the circuit. Hence, when no iron is used in the armatures it is necessary for the opposing magnetic poles to be placed as near together as possible. This is secured in the Elphinstone-Vincent machine by arranging a set of electro-magnets radially within a thin pasteboard cylinder, while a second set of magnets are fixed outside the cylinder with their poles just opposite the unlike poles of the internal magnets. The coils are flat rectangular coils of insulated copper wire, which are bent over the surface of the pasteboard cylinder, and the whole is strengthened by being tightly bound with string. There is a commutator on the axis of the armature, so that the machine forms a continuous current shunt dynamo.

In incandescent lamps, in which filaments of carbon are heated to whiteness, there is a tendency for carbon to be carried across the vacuum from the end of the carbon filaments at which the current enters, to the other end. In consequence of this, the filament gradually becomes thin at one end, and finally breaks when currents are employed always in one direction. When alternating currents are employed, the life of the lamp is said to be prolonged by 50 per cent. There is, however, some doubt about the accuracy of this statement. The life of a lamp appears to depend very much on avoiding variations of temperature when the lamp is burning. Hence it is very important to maintain a uniform speed in the dynamo.

When the current round the field-magnets of a dynamo is such that the magnets are practically saturated, any increase in speed of the armature will not sensibly alter the strength of the magnetic field, and we may say that the electromotive force will be proportional to the velocity of rotation, subject to the same limitations as in the case of magneto-electric machines. When the current is not sufficient to saturate the magnets, the electromotive force will increase in a much higher ratio than the velocity.

In an electric light installation with incandescent lamps it is generally desirable that any lamp may be ignited or extinguished independently of any other, and without wasting energy by the introduction of resistance. That this may be the case, it is necessary that all the lamps should be in parallel circuit. Thus, if there are 10,000 lamps, each having a resistance of 50 ohms, the total resistance due to the lamps when all in use will be ·005 ohm, and economy indicates that it is generally desirable that the whole resistance of the rest of the circuit, including the armature of the dynamo, should not be more than 10 per cent. of the whole resistance, otherwise more than 10 per cent. of the energy communicated to the dynamos will be wasted in heating the conductors. This necessitates armatures of extremely small resistance. In fact, for such an installation, the armature ought to have a resistance not exceeding ·0001 ohm. If the current employed be 12,000 amperes, even this resistance will involve a loss of nearly 20 horse-power upon the armature, with a generation of heat at such a rate that in one hour about 280lbs. of water would be raised from freezing to boiling point by it.

The enormous amount of copper required for the purpose renders it practically impossible to transmit a current suitable for lighting a large number of incandescent lamps from a source of power at any considerable distance from the lamps. If a certain number of lamps are to be lighted a certain amount of energy *at least* must be transmitted. Now, the horse-power transmitted is proportional to the product of the current and the electromotive force. By increasing the electromotive force we may diminish the current in the inverse ratio. But in a given conductor the heat generated depends only on the current, and is proportional to the square of the current. Hence by doubling the E.M.F. and halving the current we may run the same number of lamps, but reduce the waste of energy due to heat generated in the leads to one quarter of its former value. For this reason the higher the E.M.F. of a lamp the more economical will it be for large installations, but there is a limit to the fineness of the carbon filament permissible, and it is therefore necessary, when the power for a large number of lamps has to be transmitted over a great distance, to adopt some means whereby a current of high electromotive force may be transmitted through the main leads, and the energy of this current employed for the production of a larger current of lower E.M.F. suitable for the lamps, the conversion being carried out in the immediate neighbourhood of the lamps. If, for instance, the lamps require an E.M.F. of 100 volts and a current of 1,000 amperes, and if we wish to reduce the loss of energy in the leads to 10 per cent., we shall require a certain weight of copper for the conductors; but if we can send a current of 100 amperes at 1,000 volts instead, we may use a conductor of 100 times the resistance—that is, of only one per cent. of the weight—of that otherwise required, and the heat generated, and therefore the waste of energy, will be the same as before. Of course, the conversion from high potential current to low cannot be effected without some waste of energy, but this waste may be reduced to something like 10 per cent., and, of course, the best method of conversion is that which makes this waste the least.

Two methods of conversion have been adopted. The transformers of Gaulard and Gibbs, of Zipernowski and Déry, and of Ferranti, are induction coils through the primary of which is sent a rapidly alternating current of high potential which may be derived from a dynamo at a very considerable distance. The secondary coil is in circuit with a certain number of lamps, and having a low resistance is adapted for the production of a large current of comparatively small electromotive force. The primary current may be sent in succession through a great number of these secondary generators, the E.M.F. of the current being proportional to the number of generators employed, while each secondary coil distributes its current to a certain number of lamps. Of course, in this system, both the primary and the induced currents are alternating.

The other method, by which continuous currents are

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employed and distributed, was proposed in its crude form many years ago. It consisted in using the high potential current which passed through the line to drive a motor of comparatively high resistance. The motor was to be coupled to a dynamo of small resistance, and consequently capable of generating a proportionately larger current at lower E.M.F. The current from the dynamo was to be distributed to the lamps. Instead of employing a motor and dynamo with separate field-magnets, it was easy to place two armatures on the same shaft—one of high resistance for the motor, the other of lower resistance for the dynamo. The system devised by Paris and Scott goes a step further, and secures some very important advantages. In this system the high-resistance wire and low-resistance wire are wound together to form one armature, the high-resistance wire receiving the current from the line, and the low-resistance wire distributing to the lamps. If the high-resistance wire have ten times as many turns as the low-resistance wire, the back E.M.F. of the motor will be just ten times the E.M.F. of the dynamo, while a current in the high-resistance, or motor, wire one tenth as strong as that in the low-resistance wire, will exactly balance the electro-magnetic action of the latter, and leave the motion of the armature to be opposed only by mechanical resistances (friction, &c.). Hence the induced current will never be quite ten times as great as the primary, the difference being required in order to overcome the friction.

In these notes an attempt has been made to deal with a few leading principles in a simple manner, and without the use of the higher mathematics, and in some the bearings of these principles on a few of the most important practical problems has been considered. A syllabus of a course of lectures given to the students of University College, Nottingham, has formed the basis of the papers, and in consequence of this a few historical notes and some brief descriptions of apparatus and of simple experiments have crept into them, but detailed descriptions of instruments, tables of numerical constants, and nearly the whole subject of electrical measurements have been omitted, and for these the student is referred to any standard text book on the subject.

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXVI.

BY OLIVER HEAVISIDE.

(Continued from page 213.)

Resistance and Self-Induction of a Round Wire with Current Longitudinal. Ditto, with Induction Longitudinal. Their Observation and Measurement.

When the effective resistance to sinusoidal currents is not much greater than the steady resistance, we may employ the formulæ (44*b*) (Section XXIX., July 23, 1886) to estimate the effective resistance and inductance. On the other hand, when it is a considerable multiple of the steady resistance, we may employ the simple formulæ (45*b*). But in intermediate cases, neither pair of formulæ is suitable, and it therefore happens that in some practically realisable cases we require the fully developed formulæ which are equivalent to (44*b*), but are always convergent.

Let R be the steady resistance per unit length of round wire of radius a, conductivity k, inductivity μ, and R′ its effective resistance to sinusoidal currents of frequency $q = n/2\pi$. Let also

$$z = \mu n/\mathrm{R} = \pi\mu k n a^2 = 2\pi^2 \mu k a^2 q \quad . \quad . \quad . \quad . \quad (86b)$$

Then the formula required for R′ is

$$\frac{\mathrm{R}'}{\mathrm{R}} = \frac{1 + \frac{z^2}{6}\Bigl(1 + \frac{z^2}{2^3.10}\Bigl(1 + \frac{z^2}{3^3.14}\Bigl(1 + \frac{z^2}{4^3.18}\Bigl(1 + \dots}{1 + \frac{z^2}{12}\Bigl(1 + \frac{z^2}{3.2^2.10}\Bigl(1 + \frac{z^2}{4.3^2.14}\Bigl(1 + \frac{z^2}{5.4^2.18}\Bigl(1 + \dots} \quad . (87b)$$

The law of formation of the terms is plainly shown, so that the series may be continued as far as is necessary to ensure accuracy. But so far as is written is quite sufficient up to $z = 10$.

The corresponding formula for L′, what the L of the wire becomes at the frequency q, is

$$\frac{\mathrm{L}'}{\mathrm{L}} = \frac{1 + \frac{z^2}{2^2.6}\Bigl(1 + \frac{z^2}{2.3^2.10}\Bigl(1 + \frac{z^2}{3.4^2.14}\Bigl(1 + \frac{z^2}{4.5^2.18}\Bigl(1 + \dots}{\text{Same denominator as in } (87b)} \quad . (88b)$$

Here $\mathrm{L} = \frac{1}{2}\mu$, simply. R′/R increases continuously, and L′/L decreases continuously, as the frequency increases.

The following are the values of R′/R for values of z from $\frac{1}{2}$ to 10:—

z.	R′/R.	z.	R′/R.
$\frac{1}{2}$	1·02	6	2·01
1	1·08	7	2·14
2	1·26	8	2·27
3	1·48	9	2·39
4	1·68	10	2·51
5	1·85		

The curve, whose ordinate is $\mathrm{R}'/\mathrm{R} - 1$ and abscissa z, is convex to the axis of abscissæ up to about $z = 2\frac{1}{2}$, and then concave later.

Let us take the case of an iron wire of one-eighth of an inch in radius (about No. 4 B.W.G.), of resistivity 10,000, and inductivity 100. These data give us $z = q/51$, by (86*b*). Take, then, $z = q/50$. Each unit of z means 50 vibrations per second. Thus $q = 50$ makes $\mathrm{R}'/\mathrm{R} = 1·08$; $q = 500$ makes $z = 10$ and $\mathrm{R}'/\mathrm{R} = 2·51$, or the effective resistance $2\frac{1}{2}$ times the steady.

To obtain similar results in copper, with $\mu = 1$, $k^{-1} = 1600$, making μk to be $\frac{1}{16}$ part of its former value, we require the radius to be four times as great, or the wire to be 1in. in diameter. But if it be of the same diameter, $q = 500$ will only make $z = \frac{10}{16}$, and there will be only a slight increase in the effective resistance.

In the present notation the very high speed formulæ are

$$\mathrm{R}' = \mathrm{L}'n = \mathrm{R}(\tfrac{1}{2}z)^{\frac{1}{2}}\,; \quad . \quad . \quad . \quad . \quad (89b)$$

and, by comparision with the table, we shall be able to see how large z must be before these are sensibly true. Using (89*b*), $z = 4$ gives $\mathrm{R}'/\mathrm{R} = 1·41$, much less than the real value; $z = 8$ gives 2 instead of 2·274; $z = 10$ gives 2·234 instead of 2·507. On the other hand (89*b*) makes L′ too big, but not so much as it makes R′ too small. Thus $q = 10$ makes $\mathrm{L}'n/\mathrm{R} = 2·234$ instead of 2·21, which is what the correct formula (88*b*) gives.

Probably $z = 20$ would make (89*b*) fairly well represent the resistance, as it nearly does the inductance when $z = 10$. In the case of the iron wire above mentioned, $z = 50$, or $q = 2500$, will make the effective resistance five times the steady.

If the wire be exposed to sinusoidal variations of longitudinal magnetic force by insertion within a long solenoidal coil, the effect, when small, on the coil current, is the same as if the resistance of the coil circuit were increased by the amount $l\mathrm{R}'_1$, given by

$$\mathrm{R}'_1 = \mathrm{L}_1 \times \tfrac{1}{2}\pi\mu k n^2 a^2 = \mathrm{L}_1 n \times \tfrac{1}{2}z \quad . \quad . \quad . \quad (90b)$$

(*The Electrician*, May 31, 1884, p. 55; the last equation. Also May 10 1884, equation 36). Here l is the length of the core and coil, having N turns of wire per unit length, and

$$\mathrm{L}_1 = (2\pi a \mathrm{N})^2 \mu$$

is the steady inductance, due to the core only, per unit of its length. If C_0 be the amplitude of the coil current, the mean rate of generation of heat in the core is $\frac{1}{2}\mathrm{R}'_1 \mathrm{C}_0^2$, per unit of its length.

When the effect is large, use the formula

$$\frac{\mathrm{R}'_1}{\mathrm{L}_1 n} = \tfrac{1}{2}z . \frac{1 + \frac{z^2}{2^2.6}\Bigl(1 + \frac{z^2}{2.3^2.10}\Bigl(1 + \frac{z^2}{3.4^2.14}\Bigl(1 + \dots}{1 + \frac{z^2}{2}\Bigl(1 + \frac{z^2}{2^3.6}\Bigl(1 + \frac{z^2}{3^3.10}\Bigl(1 + \dots} \quad . \quad . (91b)$$

(*Electrician*, May 10, 1884, p. 606, equation 36) and the following. I have slightly changed the notation to suit present convenience, and show the law of formation of the terms. The old y equals the new $16z^2$.)

I did not give any separately developed expression for the L'_1 corresponding to L_1; being only a portion of the L of the circuit it was merged in the expression for the tangent of

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the phase-difference. (*The Electrician*, May 31, June 14, 1884). Exhibiting now L'_1 by itself, we have this formula :—

$$\frac{L'_1}{L_1} = \frac{1 + \frac{z^2}{6}\left(1 + \frac{z_2}{2^3.10}\left(1 + \frac{z^3}{3^3.14}(1 + \dots\right.\right.}{\text{Same denominator as in (91}b\text{)}} \quad . \quad (92b)$$

Notice that the numerators in (91*b*) and (88*b*) are the same, and that those of (92*b*) and (87*b*) are the same.

Lord Rayleigh (*Phil. Mag.*, Dec. 1886, now reprinting in this journal) does not appear to be aware of my previous investigations of the reaction of the core on the coil current, and the extra resistance due to the core.

At the frequency 500, using the same iron wire above described, we have, taking $z = 10$ in (91*b*) and (92*b*),

$$R'_1 = \cdot 188\ L_1 n\ ; \qquad L'_1 = \cdot 225\ L_1 \quad . \quad . \quad (93b)$$

Or, with a little development,

$$R'_1 = 622\ L_1 = 243{,}000\ N^2 \quad . \quad . \quad . \quad . \quad (94b)$$

i.e., the extra resistance is 243 microhms multiplied by the length of the core, and by the square of the number of windings per unit length. At this particular speed the amplitude of the magnetic force oscillations at the axis of the core is only one-fourteenth of the amplitude at the boundary. When it is the current that is longitudinal, it is the current density that is only $\frac{1}{14}$ its boundary value at the axis. There are several waves in the wire or core, in spite of its smallness, considered as a core.

Now, as cores may be so easily taken thicker, it is desirable to also have the high-speed formulæ corresponding to (91*b*) and (92*b*), which I now give. They are

$$R'_1 = L'_1 n = \frac{L_1 n}{(2z)^{\frac{1}{2}}} \quad . \quad . \quad . \quad . \quad (95b)$$

The value $z = 10$ is scarcely large enough for their applicability. Thus (95*b*) give (same iron wire)

$$R'_1 = L'_1 n = \cdot 223 L_1 n \quad . \quad . \quad . \quad . \quad (96b)$$

instead of (93*b*), making R'_1 too big, and L'_1 too small, although the latter is nearly correct.

In one respect the reaction of metal in the magnetic field on a coil current is far simpler than the reaction on itself when it contains the impressed force in its own circuit. If we have a sinusoidal current in a coil, subject to

$$e = RC + L\dot{C}$$

e being the sinusoidal impressed force, C the current, R and L the steady resistance and inductance of the circuit; and we, by putting metal in its magnetic field, induce currents in it, and waste energy there, we know that the new state is also sinusoidal, subject to

$$e = R'C + L'\dot{C}$$

where R′ and L′ have some other values. So far is elementary. This, however, is also elementary, that R′ must be greater than R. For the heat in the coil per second is $\frac{1}{2}RC_0^2$, and the total heat per second is $\frac{1}{2}R'C_0^2$. As this last includes the heat externally generated, R′ is necessarily greater than R. But this simple reasoning, without any appeal to abstrusities, breaks down when it is the wire itself in which the change from R to R′ takes place, and we require to use reasoning based upon the changed distribution of current.

To observe these changes qualitatively is easy enough. But quantitatively and accurately it is another matter. It cannot be done with intermittences. A convenient little machine giving a strictly sinusoidal impressed force of good working strength, adjustable from zero up to very high speeds, is a thing to be desired. But we may employ very rapid intermittences with an approximation to the theoretical results. The best results I have obtained with a microphonic contact, without interruptions, but it was difficult to keep going uniformly. Low-speed intermittences give widely erroneous results, *i.e.*, according to the sinusoidal theory, which does not apply, making the changes in resistance and inductance much too large. Here, of course, the silence is a loud sound, the best minimum to be got.

I should observe, by the way, that a correct method of balancing is presumed. In Prof. Hughes's researches, which led him to such remarkable conclusions, the method of balancing was not such as to ensure, save exceptionally, either a true resistance or a true induction balance. Hence, the complete mixing up of resistance and induction effects, due to false balances. And hidden away in the mixture was what I termed the "thick wire effect," causing a true change in resistance and induction (*The Electrician*, April 23, 1886). In fact, if I had not, in my experiments on cores and similar things, been already familar with real changes in resistance and inductance, and had not already worked out the theory of the phenomenon of approximation to surface conduction (first general description in *The Electrician*, Jan. 10, 1885, p. 180, of which I gave an expansion in *The Electrician*, April 23, 1886, p. 471) on which these effects in a wire with the current longitudinal depend, it is quite likely that I should have put down all anomalous results to the false balances.

Of course, we should separate induction from resistance. Perhaps the simplest way is that I described (*The Electrician*, April 30, 1886) of using a ratio of equality, reducing the three conditions to two, ensuring independence of the mutual induction of sides 1 and 2, and also of sides 3 and 4 (allowing us to wind wires 1 and 2 together, and so remove the source of error due to temperature inequality which is so annoying in fine work), and requiring us to merely equalise the resistances and the inductances of sides 3 and 4, varying the inductance to the required amount by means of a coil of variable inductance, consisting of two coils joined in sequence, one of which is movable with respect to the other, thus varying the inductance from a minimum to a maximum—an arrangement which I now call an Inductometer, since it is for the measurement of induction. The oddly-named Sonometer (the "beautiful sonometer," as it was termed by some one) will do just as well, if of suitable size, and its coils be joined in sequence. The only essential peculiarity of the inductometer is the way it is joined and used. This method of equal ratio was adopted by Prof. Hughes in his later researches (*Royal* Society, May 27, 1886); he, however, varies his induction by a flexible coil, which I hardly like. Lord Rayleigh has also adopted my method of separating induction from resistance, and of varying the inductance. (*Phil. Mag.*, Dec., 1886.) I found that the calibration could be expeditiously effected with a condenser, dividing the scale into intervals representing equal amounts of inductance. Lord Rayleigh does, indeed, seem to somewhat approve of Prof. Hughes's method, with its extraordinary complications in theoretical interpretation (very dubious at the best, owing to intermittences not being sinusoidal). But if it be wished to employ mutual induction between two branches to obtain a balance, there is the M_{63} or M_{64} method I described, which is, like the method of equal ratio, exact in its separation of resistance and inductance, with simple interpretation. I have since found that there are no other ways than these, except the duplications which arise from the exchange of the source of electricity and the current indicator. Using any of these methods, we completely eliminate the false balances; now we shall have perfect silences, independent of the manner of variation of the currents, whenever the side 4, containing the experimental arrangement, is equivalent to a *coil*, with the two *constants* R and L, and can therefore equalise a coil in side 3 (presuming that the equal ratio method is employed). But if in the equation $V = ZC$ of the experimental wire, Z is not reducible to the form $R + L\ (d/dt)$, it is not possible to make the currents vary in the same manner in the sides 3 and 4, and so secure a balance. That is, we cannot balance merely by resistance and self-induction, the departure of the nearest approach to a balance from a true balance being little or great, as the manner of variation of the current in side 4 differs little or much from that of the current in its ought-to-be equivalent side 3. The difference is great when a coil with a big core is compared with a coil without a core, and, as in all similar cases, as before remarked, at a moderate rate of intermittence, we must not apply the sinusoidal theory to the interpretation. If we want to have true balances when there is departure from coil equivalence, we must specialise the currents, making them sinusoidal. Then we can have silences, and correctly interpret results. We appear to have false

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balances. But they are quite different from the before mentioned false balances, as they indicate true changes in resistance and inductance, owing to the reduction of Z to the required form, in which, however, the two "constants" are functions of the frequency.

(*To be continued.*)

LITERATURE.

Electricity in the Service of Man: A popular and practical treatise on the applications of electricity in modern life. From the German of Dr. ALFRED RITTER VON URBANITSKY. Edited, with copious additions, by R. WORMELL, D.Sc., M.A., with an introduction by JOHN PERRY, M.E., F.R.S,, with nearly 850 illustrations. (London, New York, and Melbourne: Cassell and Co.)

A year or two ago a work in two volumes entitled "The Modern Applications of Electricity" was issued to the English public, and now we have another book of the same class from another publisher. The former was translated from the French, the latter is from the German. Patent medicines are sold by advertising, so are these books; and the books are like the patent medicines, they are made to sell. In the books there is much that is good, much that is bad, and much that is indifferent. Our wonder is that men of the calibre of Dr. Wormell and Prof. Perry can be found to put their names on such works. Publications in 1886, in our opinion—which is probably not worth much—should have suppressed the mention of dynamos and lamps which are quite out of date and superseded by machines of new and improved design, unless the intention was to trace the evolution of the modern dynamo. Do Messrs. Siemens now approve of machine Fig. 261, page 276, or Edison machines Figs. 262, 263? Is it right in 1886 to call Fig. 438 an illustration of the miner's lamp, or Fig. 440 that of a miner's Swan lamp. (Should not this be Swan's miner's lamp?) Where is Brougham's lamp, Fig. 458, used? Similar questions might be asked *ad infinitum.* So far as we can judge everything in the shape of a picture has been dragged into the book, and so we get nearly 850 illustrations, but *not* of the applications of electricity to modern life. Another series of questions might be asked, such as why Fig. 584 is called a "*galvanoplastic* bath"; why on page 418 we have dimensions in *inches*, on page 434 in *millimetres;* foot-pounds on page 440, *centimetres*, &c., on page 441; £ s. d. on page 448, while on page 401 we are treated to Austrian currency, whatever its value may be; on page 402 we have resistance in units, but what *units* we are not told.

This book is for English readers, and may be safely predicted to form a delightful study to philologists of 500 years hence. We all know John Bull's failing; how he apes the peculiarities of everybody else; how 'Arry, the tourist, tries *Antwerp* to start with, *Anvers* when he gets through Belgium, and *Antwerpen* when he gets back into Belgium. Shake the medicine and take it three times a day, all that is necessary to do good being faith in the efficacy of the dose. Here is a book which presents a delightful jumble of sound science, of charlatanism, of good illustrations and excellent descriptions, of out-of-date illustrations and feeble descriptions—a book that raises the ire of the unbiassed critic in that he sees the possibilities, which, if rightly worked, would have given the best popular treatise on the subject; but, of course, the grand thing is to have "faith in its correctness, when lo! and behold, it shall be correct."

There may be good answers to the questions we have asked, there may be good reasons for incorporating those portions of the book we have hinted should be left out, and we hesitate to insist upon our view, seeing that two of our ablest men of science, not to speak of the translator, Mr. Emil Berger, and the author, have put their *imprimatur* on the work. We who sit at the feet of the Gamaliels speak but with fear and trembling, it is the masters who speak with authority; hence we conclude with stating that this work contains 845 pages of letterpress, illustrated with 836 illustrations, printed in clear type, upon good paper, not wanting in a lengthy index, and is strongly bound in a cover of neat design. The letterpress is divided into two parts, treating respectively of the principles and the technology of electricity. *Cui bono?*

OBITUARY.

We regret to have to record the death of Colonel Sir John Bateman-Champain, R.E., K.C.M.G., who died at San Remo on the 1st inst. He was born at Gloucester-place, Portman-square, London, on 22nd July, 1835, and received his education principally at Cheltenham College.

In 1851 Mr. Champain entered Addiscombe Military College as a cadet, and obtained a commission as first engineer of his term, in June, 1853. After spending the usual two years completing the military engineer course of instruction at Chatham, he proceeded in May, 1855, to India, and served as adjutant of the Bengal Sappers and Miners, from the beginning to the end of the Mutiny of 1857-58, including the siege of Delhi (wounded), the capture of Lucknow, the taking of Jugdeespore, and many minor actions. After the fighting was over he was appointed an executive engineer in the Public Works Department, and held charge in that capacity, first of Goudah, in Oude, and afterwards of Lucknow. In 1862 (February) he was ordered to join the late Lieut.-Colonel Patrick Stewart, R.E., C.B., as his assistant. That officer had been deputed by the Government of India, after the failure of the original Red Sea cable, to examine the route by the Persian Gulf, with a view to connecting the Indian with the European telegraph systems by way of Turkish Arabia, possibly of Persia. Colonel Stewart's proposals were eventually approved, and Colonel Champain was deputed, with a staff of officers and men, to construct a land line of telegraph from Bushire to Teheran, and one from Teheran to Baghdad, a length of 1,300 miles. This was completed in 1864. He was connected since that time with what is now the Indo-European Telegraph system. He had charge, as Director-in-Chief, of this department for about fifteen years, and served in it for nearly twenty-three years. It was his duty to aid in arranging many telegraphic questions with foreign Administrations, to draw up and assist our Minister at Teheran in passing the Telegraph convention, under which we now work most harmoniously with Persia. He attended as delegate for India at several of the International Telegraph Conferences; as, for example, Berne, Rome, St. Petersburg, and London. He also attended in the same capacity at the two recent conferences held in Paris to provide for the better protection of submarine cables. In 1879 Colonel Champain had the honour to be elected President of the Society of Telegraph-Engineers and Electricians, and he was a member of the Council of the Royal Geographical Society, and an Associate of the Institute of Civil Engineers. Her Majesty, at the close of 1885, was pleased to confer the distinguished honour of Knight Commander of the Order of St. Michael and St. George on Colonel Bateman-Champain, a distinction we consider well deserved. The last principal work for the department which he effected was the superintending of the manufacture and laying of a cable of rather more than 500 miles in length, in the Persian Gulf, from which he returned on the 6th January last year. It may be mentioned in this connection, that in 1868, when he started on a similar expedition in the "Carnatic," he suffered shipwreck in the Red Sea.

In 1885, he received the Sword of Honour from the Shah, by whom he had been previously decorated with the Order of the Lion and the Sun of Persia. During the last Persian famine (about 1870-1) he took a prominent part on the Mansion House Relief Committee, doing signal service in the distribution in Persia of the fund collected in this country.

He was an Associate of the Institute of Civil Engineers. A few weeks ago, in failing health, he was persuaded to go to Cannes, but it was too late, and he died just after a removal to San Remo. During his few years' employment in Persia his character made a strong impression on the people and officials of that country. Sir John Bateman-Champain married a daughter of the late Sir Frederick Currie, and leaves a family.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of January was 3,956, estimated to produce £3,200, against 3,485 messages, producing £2,891, in the corresponding month of last year. The traffic receipts for the month of October, estimated at £2,400, realised £2,413.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 275
Elementary Electricity and Magnetism—II. (Concluded.) 280
Electromagnetic Induction and its Propagation. By Oliver Heaviside. (Continued.) ... 281
Literature ... 283
Obituary ... 283
EDISON AND SWAN *v.* WOODHOUSE AND RAWSON ... 284
Correspondence ... 285
Incandescent Lamp Manufacture.—VI. By J. Swinburne 286
Telephonic Investigations. By Prof. Silvanus P. Thompson, D.Sc. ... 287
Legal Intelligence ... 291
Companies' Meetings—
Cuba Submarine Telegraph Company ... 295
Companies' Share List ... 296
Traffic Receipts ... 296

EDISON AND SWAN versus WOODHOUSE AND RAWSON.

Whatever satisfaction may have been felt at the decision of Mr. Justice BUTT last May in the case of EDISON and SWAN *versus* WOODHOUSE and RAWSON has been at least partially disturbed by the judgment on appeal delivered by Lords Justices COTTON, FRY, and BOWEN on Monday last. Technically Mr. Justice BUTT'S judgment is confirmed, as two of the three judges were in favour of that course. But with the opinion of so high an authority as Lord Justice COTTON distinctly in the other direction, the legal pronouncement loses much of its weight; and by leaving the position of the original patents in some uncertainty may offer temptations to assail them, which can only result in a great expenditure of time and money, with no practical gain to anybody but members of the legal profession. This divergence of opinion between Lord Justice COTTON and his colleagues is, we should imagine, the only inducement for the litigants to carry the case to the House of Lords. But this inducement must not be lightly yielded to, as it is extremely improbable that the House of Lords would reverse the decisions of two lower courts. In short, we think that substantial justice has been done, though we cannot endorse all that has been said for the winning side.

It was, for example, impossible for us to accept Mr. Justice BUTT'S definition of a carbon filament, a definition which is upheld on Appeal, but which would seemingly exclude Mr. SWAN'S carbon, and by implication include the CRUTO and BERNSTEIN carbons. But apart from all definitions, accurate or inaccurate, narrow or comprehensive, the EDISON AND SWAN COMPANY are in possession of one or more carbon filaments and processes which were undoubtedly the first practical realisation of a successful incandescent lamp; and it would have been an unfortunate circumstance if their great achievement had been upset by a mere technical flaw, or by a rival whose chief merit seemed to be that its manufacture was a trade "secret." Mr. EDISON'S claim No. 2 set forth "the combination of a carbon filament within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted for the purposes set forth." We do not think that this claim will cover every conceivable improvement in the character of the enclosed filament, or of the combination as a whole; but we do think it covers the WOODHOUSE AND RAWSON lamp, and shall continue to think so until the disclosure of its "secret" manufacture reveals some exceptional excellence which at present we are unable to see. We have no objection to secret processes, but so long as patent laws exist for the protection of disclosed inventions it would be a flagrant injustice to allow them to be overridden by methods outside the range of the Patent Laws.

The appellants in this case, however, relied on something beside their superior and secret process. Their contention was that the patented inventions of SWAN and EDISON had been anticipated; and a great deal of evidence, most of which has been made familiar to our readers from time to time in these columns, was adduced in support of this view. In this respect Messrs. WOODHOUSE and RAWSON, it must be admitted, have acted with perfect consistency. Holding, as they do, that what may be called the essential features of the modern incandescent lamp had long ago been known, though not in a practical form, they protected themselves by a process of their own kept secret; and this is the only way open to inventors of valuable improvements on processes which for legal reasons cannot be patented. But, as we have already stated, the principles underlying an invention may be well known without invalidating a subsequent application of them to practical purposes never previously foreseen, or at all events never acted upon. Mr. SWAN and Mr. EDISON both succeeded in doing what people before them had failed to do—namely, to make the incandescent electric lamp a serviceable and marketable commodity. Lords Justices FRY and BOWEN even declared that "there was no evidence to show that any lamp was ever made under any of the numerous patents, which seemed strongly to point out that everyone of the ingenious apparatus devised (previous to that of SWAN and EDISON) was a failure." No lamps of the kind were sold or used before 1879, whereas tens of thousands of them were made and used after that date. We think this fact conclusive on the question of anticipation.

It is fair to add, however, that in one respect the appellants were handicapped by a circumstance which was peculiar to the case, namely, the fact that Mr. SWAN had thrown in his lot with the EDISON COMPANY, and that he had ceased to have any interest in asserting his own claim to priority against Mr. EDISON. It was contended on behalf of Messrs. WOODHOUSE and RAWSON that Mr. SWAN'S lamp, shown at Newcastle prior to EDISON'S patent, invalidated the latter. If the action had been SWAN against EDISON we should have said so too; but as touching the WOODHOUSE AND RAWSON lamp the plea is a purely technical one. Still, the appellants were entitled to avail themselves of it, and it seems to us they suffered by not having Mr. SWAN on their side. With his assistance they might possibly have overthrown the EDISON patent; but it was hardly to be expected that he would sacrifice himself for the benefit of a new claimant, whose title to consideration is at least problematical, even had his engagements with the EDISON AND SWAN COMPANY left him free to do so. Lord Justice COTTON was plainly of opinion that the SWAN lamp anticipated EDISON'S in respect to the carbon filament; and if

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this view had prevailed with the other two judges, the present appellants might possibly have established a right to manufacture their own lamps—supposing they were proved to be made on a novel, as well as a secret principle.

CORRESPONDENCE.

PRIMARY BATTERIES AND ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You were good enough in a former letter to mention my primary batteries, and I think, perhaps, your readers may be interested to read how readily they adapt themselves to private as well as public dramatic entertainments. During the past fortnight we have given six entertainments to the members and associates of the Primrose League in our own and the adjoining parishes. The performance—varied, as you will see by the enclosed programme, by the introduction of weird scenes from the ghastly legends of "The Dead Drummer of Salisbury Plain," and the armoured spectre in "Alonza the Brave"—was exceptionally novel, owing to the introduction of the electric light into the cavernous eyes of the spectre while it and the fair, but faithless, form of Imogene were enveloped in a halo of misty blue. By the use of a triple flexible cord, manufactured by Messrs. Phillips and Co., a suspended drum discoursed an accompaniment to the piano in a style not to be accomplished with ordinary drumsticks, and the poor little drummer boy on Salisbury Plain, with his white, dead face and wound on the left temple, frightened his murderer into confession by his mysterious drumming during the intervals of a thunderstorm. At the close of the performance a young lady dressed as a fairy appeared, her skirts of blue tulle looped up with bouquets of primroses, in which sparkled a number of small electric lamps; while from her left shoulder gracefully descended a wreath formed in the same manner.

A pretty effect was given by means of the light of lamps of high power being thrown through coloured glasses on to the fairy's little figure, while presently a wave of the wand released a spring, and scattered primroses amongst the audience, and also caused a magic box, suspended from the ceiling, to open and shower down its contents (cosaques and bonbons) pell mell into their laps. For ordinary lighting purposes lamps of various power were suspended in the theatre and rooms, and used as occasion required, all being entirely under the control of the manager in one spot at the "wings." Pray excuse my troubling you with this very unscientific letter; but I would mention that the large cells I used, with the exception of some "refreshing" once only, have been charged since January 18th, and have been running four hours for six nights of the entertainment, and over two hours for every other night, and are still capable of lighting my large dining room with five 8-candle 16-volt lamps brilliantly, or my drawing room with nineteen 5 candle-power 10-volts. A small battery of eight portable cells was used during the time for lighting the piano and back scenes, &c., and part of the church on Sundays, and still retains considerable power. The large primary cells, which I used for the theatre and principal effects, were placed nearly 300ft. away from the lamps, and took that length of cable to convey the current, whilst 218ft. of double flexible and chandelier wire, and 100ft. of single wire were used in the installation.

Yours, &c., CHARLES PENRUDDOCKE.

Compton Park, Feb. 1, 1887.

SOLDERING ALUMINIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having seen several inquiries as to the soldering of aluminium, perhaps you will allow me to mention a plan that I devised in order to make some galvanometers. First electrotype the aluminium with copper; this should be done slowly, so as to get an adherent coat. Common sulphate of copper solution will answer, but an alkaline solution is, I think, the best. Then use an ordinary soldering bit and any common solder. For a flux chloride of zinc will answer, but as all acid fluxes are objectionable owing to the creeping of the acid, I prefer to use resin, which does very well. Perhaps some of your readers would try this, and give the benefit of their experience.—Yours, &c., H. CUNYNGHAME.

Stanley-lane Lodge, Fulham.

THE ELECTRIC LIGHTING OF MINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Last year I had the honour to give a lecture on this subject before the members of the Manchester Geological Society, which at the time raised an animated discussion among the members present, many of whom were mine owners, mining engineers, or colliery managers. Among those who took part in the after discussion was Mr. Miles Settle, of the Madeley Coal and Iron Company. He, with others, doubted the feasibility of carrying the current from a dynamo up to the working face, and working an ordinary incandescent lamp. Imagine, then, my surprise and pleasure when I learned that he and two others had taken out patents for the protection of the incandescent lamp while being used as the sole illuminant in winning coal.

Mr. Settle kindly invited me to visit the Leycett Colliery, Madeley, to see his protection lamp in actual use in the main ways and at the coal face. On arriving at Leycett Colliery we inspected the various experimental systems for protection of the lamp which Mr. Settle had been trying. We descended the downcast shaft, 300 yards deep, and found the main ways lit up by the incandescent lamps suspended from the roof and enclosed in the protectors. Passing by the furnace and boilers, we entered a passage in the main airway, and here the dynamo was at work (an ordinary Gramme, and working badly). We tested the machine and then inspected the manner of carrying forward the main leads to the upcast shaft. Re-entering the cage, we descended 230 yards further. We then proceeded along the main way, which was lighted throughout its length by incandescent lamps, and entered the headings. Our light now was the "Meuseler" safety lamp, which each one carried, and we followed the mine manager, noting by the way the rough but thoroughly practical system of casing which is used for carrying the cables and derivations up to the working face. Arrived there we found the collier preparing for a "shot." The protected 16-20 Edison-Swan lamp was hanging here, as in the main ways, 12ft. from the "face." The blast hole was ready, and Mr. Dickinson prepared to show us that the risk of danger from blasting coal was reduced to its minimum. Mr. Settle is the inventor of the "water cartridge." This in reality consists of a "sausage" of gelatine dynamite, which is placed inside a tin case, open at both ends, and with straight cuts for about ½in. from either end. The detonator, having two insulated wires, is pressed into the dynamite, and the "lugs" are pressed one-half over the ends to keep in the compound, and the other half turned outward, so as to keep the tin case in the centre of the water bag in which it is placed. This done, the end of the water bag is tied, the cartridge is pressed gently home, the usual "tampings" done, and the electric wire attached. The blasting cable was made fast to the magneto machine (portable, and in a strong box). An eighth of a turn of the handle, and a heavy concussion was felt. In half a minute we were examining the won coal. No flame was visible; the work was simply perfect, tons of coal coming down at one blast—not shivered, as in the case of gunpowder, but good "round" coal. It is worthy of note that the seam is 10ft. thick, admittedly one of the most fiery in the kingdom.

With electricity to illumine the mine and to blast the coal, the terrible annual "death roll" must be greatly lessened. This, if nothing else were gained, is surely a great step. Mr. Settle's protector is as ingenious as it is simple. The lamp is placed within a small strong glass shade. This is attached to a float or piston, and a larger glass cover comes over all. The outer vessel may be filled with water, air, or carbonic acid gas. When either is forced into the vessel the lamp and its inner protection rises, thus making contact, and the lamp is in work.

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If by accident the outer shell is broken the lamp falls instantly, going out and cutting off the current.

Mr. Ellis Lever has pointed out the great improvements brought out of late in electric safety lamps, and writes confidently of their exclusion of "flame" lamps. Would it be possible, Sir, to persuade Mr. Lever to reiterate his offer of £500 for the best safety lamp or system of protecting under all the conditions previously laid down by him? Such a stimulus would be sure to bring to the front the result of much thought and practical experience on this question.—Yours, &c.,

THOS. CONNOLLY.

The Elms, Hendam Vale, Queen's Park,
Manchester, Feb. 2, 1887.

ELWELL-PARKER DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you allow me to state that the arrangement and proportions of the heavy fly-wheel and bearings of the Elwell-Parker two-pole dynamo which you describe and illustrate on pp. 257-8 of your last issue were specially designed by me for an installation which Messrs. Elwell-Parker (Limited) carried out under my superintendence.—Yours, &c.

Feb. 1st, 1887. HENRY LEA.

INCANDESCENT LAMP MANUFACTURE.—VI.

BY J. SWINBURNE.

Amyloid Carbon. (*Continued.*)

Messrs. Mortimer Evans, Powell, and Wynne have taken out patents for processes of making amyloid thread from solution of cellulose in zinc chloride. What is wanted for such processes is a perfectly smooth solution of cellulose which is thick enough to flow slowly through a nozzle into some liquid that will cause it to set. The chief difficulty is in obtaining a smooth solution of cellulose that is permanent. Many solutions contain lumps of jelly, and these lumps, though not visible on looking through the solution cause the issuing stream to form irregularities and elbows. Another trouble is the presence of little bubbles of air which are held in the liquid because they are too small to rise through the viscous mass. When a little bubble goes through the nozzle it gets squeezed either smaller or into a different shape, and directly it gets through, and before the issuing stream is set, it returns to its original form and causes a lump and a bend. When dried the threads shrink enormously, and the presence of the little bubbles is fatal, as the thread always breaks. The writer was experimenting with solutions of cellulose in zinc chloride when Messrs. Evans, Powell, and Wynne's patents came out; but he did not get good results with the solution described by them, though a slightly different solvent was more promising. As he found the processes were protected, he did not continue his experiments.

Messrs. Evans, Powell, and Wynne use a neutral solution of zinc chloride in water, and dissolve cellulose in it. The solution, as described in the specifications, is made by dissolving zinc in dilute hydrochloric acid in the presence of excess of zinc until effervescence practically ceases. The solution is then shaken up with carbonate of zinc to ensure that it is neutral. The solution is then filtered, and concentrated to a sp. gr. of 1·8. Cellulose in the form of absorbent cotton is then stirred into the solution kept at 100°C. till it is sufficiently thick. The writer does not find such a solution dissolve cellulose properly; it appears to be too weak, and is better a little stronger. If made much stronger, it does not act well either.

The solution is made by this process instead of by dissolving commercial zinc chloride in water, because commercial zinc chloride has been concentrated by evaporating a solution down, and finally fusing the salt. At the necessary temperature the salt appears to absorb oxygen from the air give off chlorine, or else to give off hydrochloric acid, so that there is some basic chloride formed. The writer finds the solution of fused zinc chloride just as good as that prepared without fusion, though it is not so clear. According to the specification the little bubbles are got rid of by sucking the solution of cellulose through a gun-cotton or glass-wool filter, and then heating it in vacuo. This method, with ordinary filter paper and with an acetic acid solution, might be useful in Swan's squirting process also. Of course an ether solution of pyroxylin would not stand a vacuum.

The solution, which we will suppose to have been made beautifully smooth and even with a solution of zinc chloride of 1·8 sp. gr., is now placed in a glass vessel drawn to a nozzle at the lower end. If the solution is thin enough it slowly and evenly moves through the nozzle, and as it comes into the fixing liquid it sets and coils itself on the bottom of the vessel with the most beautiful regularity. The processes for squirting amyloid threads are very pretty.

If the solution is thick it will require some pressure to force it through. The most convenient way of applying pressure is by means of an air compressing pump, or syringe, or it might be kept steady for a long period by means of a carbonic acid or hydrogen generating apparatus, with a fall tube long enough to give the exact pressure desired. Squirted threads generally come out smoothest when the solution is not too thick. The most natural mistake is to use a solution that is not thin enough to run through the nozzle well.

The liquids described for precipitating the cellulose, or making the issuing thread set, are alcohol, ether, acetic ether, acetic acid, ammonia, and glycerine. The writer used water, but some of the other substances may be better. The patentees do not mention water. They mention fixing the thread with ether or alcohol vapour, which seems rather impracticable. The solution they prefer is slightly acidulated alcohol. They describe series of vessels containing fixing liquid and rollers to convey the thread from one to the other. A running stream of water washes the thread very well.

When washed it is dried in the usual way, and it should then have a high polish, and should be quite uniform in cross-section. Very good lamps are said to be made by the Anglo-American Brush Corporation, who own this patent.

Solutions of dextrin and glucose are also mentioned. They will probably be as efficient as Swan's nitro-glucose solution. Various other solutions of cellulose can be made.

The writer has made experiments with several. Very strong hydrochloric acid makes a sort of solution of cellulose, but it does not quite destroy the fibre, and on examining it by reflected light, the solution is seen to contain very short pieces of fibre floating about. It also turns very rapidly into dextrin. For zinc chloride solutions the addition of hydrochloric acid is beneficial. A solution of zinc chloride in equal parts of hydrochloric acid and water works well. The chalky appearance of the solution of fused zinc chloride in water disappears when hydrochloric acid is added.

Phosphoric acid can be used to make a cellulose solution. The phosphoric acid may be prepared by exposing phosphoric anhydride to the air and letting it diliquesce. Phosphoric acid solution of cellulose is difficult to make, but it does not rapidly turn thin from formation of dextrin.

Sulphuric acid can be used as a solvent for cellulose, but its action is too rapid for it to be of much use in squirting. The right strength must be determined by adding water drop by drop to acid till the solution is just effected easily and thoroughly. The exact strength depends on the temperature. Glacial phosphoric acid seems to check the formation of dextrin, and should be added to the dilute acid. Water is used as the setting liquid. A little ammonia may be added if it is desired to make the issuing stream set more quickly. The best way of making squirted thread by means of sulphuric acid is to dip a piece of absorbent cotton into it, and immediately put it into the nozzle-ended tube. The mass of cotton soon begins to soften and then runs through. Thread made this way is very strong and has a good bright finish, but the want of permanence of the solution prevents its being made of a known strength, and it gets thinner and thinner while the thread is being formed. A sulphuric acid solution will not last more than ten minutes altogether, and it is getting gradually thinner all that time. The thinner the solution is, the quicker must be the action of the setting liquid. The result of this is that when the solution is very thin and a quick acting setting liquid is used, the

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issuing stream is coagulated at the surface immediately it touches the liquid, and a tube is formed which protects the interior for the moment. This tube is apt to burst every here and there, and the cellulose solution squeezes out and solidifies, making little lumps like those formed when a cracked egg is boiled. Even if these little nodules are not formed the thread is apt to consist of a tube with a loose inside, or it flattens out before setting. These troubles are apt to arise in all squirting processes.

The solution of cellulose in cuprammonia can be squirted. Absorbent cotton is stirred into the blue solution, and left till as much as possible has been taken up. The solution is then decanted off, or any undissolved cotton is removed with a glass rod. It is generally best to add a little more cuprammonia to dissolve any stray pieces that may be floating about. The resulting solution is too thin for use, so it is concentrated by evaporation. Though the cuprammonia was saturated with cellulose to begin with, it may be concentrated by evaporation without throwing the cotton down. The solution is either left exposed to the air, or slowly boiled. It must be slightly stirred to prevent the formation of a skin over the surface. When sufficiently thickened the solution is poured into the nozzle glass. Dilute acetic or other acid is used as setting liquid. The blue thread is first turned opaque green, and as the oxide of copper is dissolved out it whitens. Acetic acid is safer than mineral acids, as if any traces of it are left in the thread it volatilises when heated without destroying the amyloid. The thread shrinks very much on drying, and becomes very transparent.

Mr. Ram, who has lately been working out different methods of squirting thread, tells me he finds it advantageous to remove the copper from the solution of cellulose before squirting. Mr. Ram places rods of metallic zinc in the cellulose solution, and this withdraws the copper and substitutes zinc without precipitating the cellulose. Perhaps cellulose may be soluble directly in a zinc ammonia solution, and if a denser solution of cellulose could thus be obtained it might be very valuable.

TELEPHONIC INVESTIGATIONS.*

BY PROF. SILVANUS P. THOMPSON, D.SC.

Just a decade ago electricians in bo h hemispheres were directing their attention to the perfection of instruments for the electrical transmission and reproduction of sounds. On this side of the Atlantic, Mr. Varley and Messrs. C. and L. Wray, and on the other, Messrs. Elisha Gray, Graham Bell, and T. A. Edison, were all at work. The years from 1875 to 1879 witnessed a marvellous series of improvements in telephonic instruments of all kinds, and the commencement of the exchange system. Since the latter year the development has been almost wholly of a commercial nature. If we except the researches of Graham Bell and Tainter upon the photophone, which have as yet not been made of any commercial value, it is just to say that no great scientific progress was made between 1879 and 1885; for Prof. Hughes's discovery of the microphone was made before this in 1878, and the much-applauded methods of Van Rysselberghe for the perfection of long-distance telephony are a mere commercial extension of the researches of Black and Rosebrugh in 1878-9.

Yet it cannot be said that the lull in telephonic invention and discovery has arisen from the absence of need for further improvements. The need exists for better] cheaper, more reliable instruments—for instruments less subject to interference from currents which stray into the system by induction and by leakage—for instruments which will work over longer distances. It would be strange indeed if such obvious and well-known necessities did not sooner or later engender invention. Already, indeed, in several quarters a revival of attention to this subject has been awakened. In our own metropolis Mr. Langdon Davies has produced a series of inventions which might well claim the attention of this society, comprising as they do that novel kind of transformer the phonopore, the phonoporic telegraph, and the open-circuit telephone. Already we hear of duplex and even multiplex telephony—of special methods for long-distance telephoning, and of other kindred advances. A paper recounting the inventions thus looming somewhat dimly before us might form the subject for a profitable discussion; there would at least be no lack of matter. The aim of the present writer is a far simpler and more personal one. For some three or four years he has been engaged, in the intervals of other duties, in examining various points in the theory and practice of telephony, and his researches have resulted in several forms of instruments, some of which possess new points of scientific interest, whilst others do not profess to be more than useful commercial articles in which the points of novelty are solely of an industrial order. For some months past the writer has been anxious to submit his work to public scrutiny, and to breathe the healthy atmosphere of criticism; but his ardour has been controlled by friendly advisers who counselled delay, but who, now that all fears have proved needless, have left him the desired freedom of speech.

* Paper read before the Society of Telegraph-Engineers and Electricians on January 27th.

A complete telephonic system (we are not here dealing with exchange working) usually consists of at least four parts:—

1. A transmitter.
2. A transformer, or induction-coil.
3. A circuit of outgoing and returning wires (or earth).
4. A receiver.

For transmitting both ways, all parts, save No. 3, are usually duplicated. In certain instances the transformer is dispensed with. In certain other instances transformers are used at both ends of the line—one at the transmitting station, the other at the receiving station. In some instances, though not in the first telephones nor now usually, the receiving and transmitting instruments are identical. In fact, we may classify the various systems as follows:—

I. **Transmitter < Line Wire / Return Wire > Receiver.**

II. **Receiver < Line Wire / Return Wire > Receiver.**

This is Graham Bell's system, either receiver being used as transmitter.

III. **Transmitter — Transformer < Line / Return > Receiver.**

This is the one in common use.

IV. **Transmitter — Transformer < Line / Return > Retransformer — Receiver.**

As the writer's investigations relate to transmitters, transformers, and receivers, it may be well to take up the subjects in this order.

TRANSMITTERS.

It may be convenient here to give a systematic table of all the principal classes and genera of transmitters. The three classes relate to the way in which the sonorous vibrations are made to affect the electric system, by varying (1) the resistance, (2) the electromotive force, (3) the capacity of the circuit or of a part of it.

CLASSIFICATION OF TRANSMITTERS.

I. *Varying Resistance*—	
1. Loose Contact	
with diaphragm.........	Reis, Berliner, Blake, &c.
without diaphragm ...	Hughes.
2. Liquid Resistance	
in external circuit ...	Yeates, Gray, Graham Bell, Edison.
in battery	Graham Bell.
liquid jet	Graham Bell, Ch. Bell, and Tainter.
3. Short-circuiting............	Edison.
4. Compressible semi-conductor..................	Edison.
5. Photo-electric...............	Graham Bell and Tainter.
6. Tribo-electric...............	Edison.
7. Crookes' Layer	
II. *Varying Electromotive Force*—	
1. Magneto-electric methods:—	
Moving conductor in magnetic field.......	(See *Receivers*)
Varying magnetic field around conductor	Graham Bell, &c.
Varying coefficient of mutual induction..	Spottiswoode.
Varying coefficient of self-induction	G. J. Stoney.
2. Electro-capillary	A. Breguet.
3. Thermo-electric	
III. *Varying Capacity*—	
1. Vibrating condenser plates	

My own researches in this part of the subject have been somewhat desultory. So far back as the end of 1878 I observed that if a thermopile is placed so as to receive the radiations from a singing flame, a sensitive receiver of appropriate low resistance placed in the circuit will repeat the vibrations. I devised at that date a special transmitter, in which the voice vibrations were led into a Kœnig's manometric capsule, so that the gas flame connected therewith, being thrown into vibrations in correspondence with the voice, might affect a thermo-electric transmitting apparatus.

Later, I worked at the problem of securing a more direct correspondence between the voice waves and the electric impulses of the transmitter than was the case with many of the transmitters which were used in great variety in the years 1878-82. The circumstances which in such instruments as the Blake transmitter and in the Wollaston transmitter (commonly known as the Gower-Bell) occur to cause this lack of correspondence are various. All diaphragms have tones of their own—not always well defined, but still obviously present. A diaphragm having a low fundamental tone gives the voice a "boomy" sound, while a diaphragm of too shrill a tone gives the voice a "tinny" sound. Moreover, all springs have tones of their own. Further, instruments such as the Blake transmitter, the operation of which is to open or close the contact to a greater or less degree in proportion to the vibrations, do not always do so. Some sudden, powerful sound taken up by the diaphragm gives the light contact-mechanism behind it such a sudden forcible thrust that the electrodes are forced wholly, instead of partially asunder, and the resistance, instead of varying in any exact inverse proportion to the displacement, increases suddenly to infinity. And the result is not merely a lack of correspondence between the sound-wave and the electric impulse, for, as instruments are generally arranged, another phenomenon takes place at this stage. The sudden complete parting of the electrodes is followed by a spark due to the self-induction of the circuit; and the spark, being a sudden electric

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discharge of excessively short duration, produces a harsh and loud noise in the receiver. Many persons call this noise the noise of make and break. It is nothing of the sort. Making of the circuit and breaking of the circuit can be accomplished without any such disturbance, provided the extra current sparks are suppressed. Another point is less easily stated. All the transmitters in which carbon contacts are used are defective in their transmission of certain sounds, particularly the sibilants and shrill whistling sounds. At one time I was of the opinion that this circumstance was not the fault of the transmitter at all, but arose from the receiver, which, in consequence of its self-induction, "throttled" (to use Lord Rayleigh's term) the more rapid fluctuations of the electric current. I was undeceived in this view by finding substances other than carbon which, when used for contact points in the transmitter, enabled me, while still using the existing receivers, to transmit the sibilants with extraordinary crispness. Lastly, none of the transmitters at the date in question, save the Hunnings and the Gower-Bell, were as loud as was desirable. All the others required a very sensitive receiver, with the necessary result that the receiver received too much—was so sensitive as to be subject to the intrusion of all sorts of stray electric impulses, tending to drown its own small voice. At that date the chief transmitters known were (1) the Blake, with its two contact-surfaces of good conducting matter, usually platinum and hard carbon, liable to spark at the break, difficult therefore to use in factories where there was vibration, and spoiled by being too loudly spoken to; (2) the Edison, with its button, or cushion, of semi-conducting compressible metallised fibre or mass of lampblack, screwed up so that it could not spark; (3) the many varieties of Hughes's microphonic pencils, mounted on sounding boxes in all sorts of ways—Johnson's transmitter, having two of Hughes's pencils, Theiler's having three, Crossley's four, Wollaston's ("Gower-Bell") six or eight, and Ader's twelve; (4) the Hunnings' transmitter, having a loose layer of granules of coke—a form, by the way, which has lately been revived in the States with much *éclat* for the purpose of long distance speaking, but without any single feature of novelty beyond what was known here in 1882.

The problem was to find a form of instrument which, while admitting of more powerful currents being used than was possible with any of these forms, would neither spark at the contacts, nor necessarily require the intervention of a diaphragm to collect the sound-waves. I am far from asserting that the presence of the diaphragm—and I use the word in the undistorted sense in which it was used ten years ago—is in all cases a detriment to a transmitter. On the contrary, in many cases it is extremely important to have one, in order to concentrate on a mechanism that otherwise would be inoperative the force derived from the impact of the sound-waves over a considerable area. I make use of this feature of construction in one of my most recent forms of instrument There are other forms of instrument without any diaphragm, and which are better without any.

The transmitters that I have the honour of describing to-night to the society do not pretend in any individual form to present a complete solution to the complex problem of finding the perfect telephone. Of many hundreds of forms which have successively been essayed, I will describe only a few. From the days of Bourseul's vague suggestions and Reis's early instruments, that acoustic organ the diaphragm had been deemed a fundamental feature, until Hughes showed its non-necessity. Yeates had used it, so had Varley, so had Van der Weyde. Messrs C. and L Wray had used a double diaphragm. Gray, Graham Bell, Berliner, Siemens, and Edison had all made it the starting point. The discovery that no diaphragm was necessary was proclaimed by Hughes and by Edison early in 1878. But, when one tried to construct practical microphone transmitters without any diaphragm to collect and concentrate the air-waves, it became apparent that the diaphragm had also served another function, namely, to intercept the moisture of the breath, which otherwise would condense on the electrodes and impede their action. Hence, in omitting the diaphragm in order to secure a more direct correspondence between the voice-waves and the electric impulses, it became necessary to devise means for getting rid of moisture. A short length of speaking tube furnished all that was wanted. Many experiments required, however, to be made before the best form of microphonic arrangement to suit this method of working was found. One early form of tube telephone on this plan had springy tongues of carbonised paste-board to constitute the contact-electrodes; another had a small pendulum arrangement like the electrodes of the Blake telephone. In the spring of 1884 I devised the form, to which at the time I gave the name of "Nest" telephone, because in it the working parts, instead of being mounted on springs, reposed in a sort of nest made of cotton wool or slag wool. Some nests had in them contact pieces shaped like eggs, others mere coke granules, others, like the figure,* had a central ball, E, with small microphonic pencils, G, around it, the ball resting on the bed of wool B in the nest, and the air-waves impinging through the speaking tube A, from above.

About the same time it was my fortune to have as my collaborator Mr. Philip Jolin, engineer, of Bristol, and in conjunction with him I devised another form next shown. It occurred to us that if the air-waves could bend a flat, stiff diaphragm they might be able to lift a valve, which, though incapable of bending or vibrating in itself, might follow or ride upon the vibrations of the air-waves. After a trial of many intermediate forms, some of which are on the table before you, we settled upon the pattern shown, having a polished valve-ball, V, reposing lightly upon three metal pins, P, between which it made electric contact. The speaking tube A led the voice waves to impinge on the under side of the valve, and the tube itself was clamped in a supporting bracket, S, between two rings, R, of india rubber, to prevent any stray vibrations from reaching the sensitive mechanism from the wall against which it was fixed. Concerning the material of the valve itself I will presently speak. We found that valves of many kinds—cone valves and clack valves, as well as ball valves—gave excellent results. Later it was found advisable to modify the "Valve" telephone, and to give it the form next shown, in which the valve is egg-shaped, or even pegtop-shaped, rather than spherical, and the current is led into it through a fine coiled wire; the three contact-pins (of hard Carré carbon) being united so that the three contact surfaces were all in parallel with one another. With this form stronger currents could be used. In the search after the best form to give to the instrument I was aided by Mr. John S. Sellon, who also produced several excellent transmitters having microphones of special form. In one of these a perforated ball, or bead, was slipped over the ends of two nearly-meeting cylinders, which projected horizontally over the top of the speaking-tube.

The loudness of the valve telephone is limited by the fact that it is not expedient to work with more than three contact points, the limit being a natural geometrical one familiar to every constructor. When, therefore, still louder instruments are desired, either several separate valves must be combined, or some other form of instrument must be employed admitting of a larger number of contacts being introduced. A form of instrument which answers well consists of a *grid* or row of microphonic pencils—Hughes's microphones pure and simple—mounted in an open frame, F, and provided with a convenient rubber-covered handle, H, through which the conducting wires pass. There are several ways of using the "Grid" telephone—it may be mounted above the call-bell with the handle vertical, or it may be held in the hand and simply talked to, the voice-waves striking direct upon the microphonic pencils. But there is a third way in which it may be used, namely, that suggested so far back as 1878 by our esteemed past-president, Mr. Preece, in this very room, when he showed that Hughes's microphone required no air-waves to operate it, but might be placed against the forehead, face, or breast. About the same time Prof. McKendrick found that the mechanical vibrations of the throat could work a Hughes microphone direct. The "Grid" telephone has a second handle, K, which can very conveniently be laid against the throat or breast, and it makes an admirable transmitter. I am, indeed, told that a Mr. James Lowth, of Chicago, has brought out a whole system of telephony based on this method.

Not being quite satisfied with any of the instruments which I have now described, though any one of them is quite equal to the average Blake telephone, and some better, I have designed yet another form of instrument specially for the work of long-range transmission, or where very unusually loud effects are wanted. For long I have maintained that the clue to long-range telephony is to use much more powerful transmitters and much less sensitive receivers. The more powerful transmitter will require strong currents to pass through it in order that it may produce strong variations of current. But strong currents—currents of from $\frac{1}{10}$ of an ampere to one or two amperes—are out of the question where only one or two or even six contact points are used. Too strong a current through any one contact point ruins its working. We know, both from the researches of Mr. Bidwell, from the theory of Dr. Moser, and from the experience of Wollaston and Ader transmitters, that the right solution to the problem of arranging a set of microphones in the most effective way is to place them all "in parallel" with one another, so that the main current divides itself between all the contacts. If, however, a set of microphonic pencils are placed simply all in parallel, there occurs a practical difficulty, namely, that the least sensitive microphone is that which will receive the greatest current; and, moreover, if the attempt is further made to provide the set of microphones with electricity at a constant potential, then there is a continual liability for one contact to become overheated and spoiled. The ordinary way—for example, in the Crossley and Ader telephones—of arranging microphones is to attach them side by side beneath the under surface of a sounding-board. This arrangement seems to be open to the objection that the various parts of the sounding-board do not move simultaneously in the same direction; some are heaving up at the moment when other parts are moving down. The wonder is that such a transmitter works as well as it does. The transmitter that I have constructed for this special work has many microphones—108 in all, arranged in 54 parallels, the pencils being two in series. They can also be arranged all in parallel if desired. They are grouped in multiple-grids. Each grid or layer contains 12 microphones, and the motion is communicated to them by a central vertical rod which itself receives its motion from the centre of a mica diaphragm. The impulses do not, of course, pass down the steel rod absolutely instantaneously, but the retardation of phase of even the shrillest of vocal sounds is quite negligibly small. The microphones practically act simultaneously. To each layer of microphones a small resistance coil is added, thus assimilating the practice to that adopted when a set of arc lamps are to be used in parallel. Perhaps it may be worth while to provide a small resistance to each pair of pencils hereafter. When there are so many microphones to be carried, although the voice waves are concentrated by a diaphragm of 5in. in diameter, the amplitude of vibration imparted is not very great, probably not much greater than would be imparted by the voice acting upon the microphones direct if the diaphragm were removed. This mode of using the transmitter is, by the way, quite successful. But if the number were further increased the amplitude of motion imparted by the diaphragm would be insufficient. Hence, I have sought other ways of obtaining mechanically the requisite energy, leaving the voice the work of controlling the motions. A method of doing this, which promises good results, was suggested by Edison's "motographic" receiver. Against a slowly-rotating friction-roller presses an extension of the rod that supports the central bars of the layers of microphones, and agitates them with a drag and slip motion. The voice is made to affect the pressure upon the slipping surfaces, and so control the periods of drag and slip. In experimenting in this direction several points of interest in the theory of microphonic contact presented themselves, and are worthy of attention.

* The various figures referred to were shown in diagrams on the wall.

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Effects of Heat on Microphonic Contacts.

First of these points was the effect of heat on microphonic contacts. It is a matter of common knowledge that microphonic contacts work more satisfactorily when warm than when cold. Hunnings' transmitters of granulated coke work best when heated by the current. Ochorowiczs has produced a special telephone transmitter—the details of which are still kept from publication—in which a preliminary heating is brought about by using a powerful current. I have tried various arrangements of microphones in which heat was led from a small gas jet by copper rods or tubes to heat the working contacts, but have not arrived at any final form. At one time I was under the impression that the heat served simply or chiefly to increase the energy of the vibrations imparted by the voice. But further experiment showed that this was at least a crude view, for I found that if one of the two pieces in contact was heated, the microphonic joint became more sensitive to sound when the other was kept cool. In fact, the actual transfer of heat across the loose contact of the circuit seems to facilitate its action as a telephonic transmitter. In studying this point I came upon another fact, namely, that the layer of vapour which exists between a drop of acidulated water in the so-called spheroidal state and the hot metal plate beneath it will also act as a microphonic transmitter, though from its high resistance and instability it is a rather unmanageable sort of transmitter. Now we know from the researches of Dr. G. Johnson Stoney, Prof. G. F. FitzGerald, Prof. Barrett, and Mr. R. Moss, that the layer of vapour which supports the spheroid is in the state of so-called "heat-polarisation"—that is to say, having a peculiar stress in it transversely to the layer. The researches of this group of distinguished scientific men have shown that there is a distinct relation between the stress across the layer and the difference of temperature between its surfaces. Between these layers heat is passing by a process termed "penetration" by Dr. Stoney, the essence of which is that the molecules which are travelling across the layer from the hot to the cold side are moving faster than those which are travelling in the contrary direction. That such a layer can conduct an electric current proves that the molecules in their flights across the layer carry electric charges upon them, exactly as do the flying molecules in the highly-attenuated vapour of a vacuum tube. It is, indeed, significant that our vice-president, Mr. Crookes, himself suggested, so far back as 1874, that the phenomena of the "spheroidal state" were due to the same causes as those he was studying in the repulsion which he found to exist between two bodies, one of which is hotter than the other, as in the case of the blackened vanes of the radiometer and its enclosing bulb. If this view be correct, the apparent resistance of a layer of flying particles ought to be proportional—*ceteris paribus*—to the number of molecular impacts per second, and this in turn will be proportional to the area of the layer, and inversely proportional to its thickness. It is possible that it may be a novel idea to some members of the society that if an insulated conductor of a given size is flying backwards and forwards in a regular periodic manner between two surfaces, one of which is at a higher electrical potential than the other, it will act as a conductor of measurable apparent resistance. An ordinary electric bell while ringing possesses a measurable apparent resistance quite different from its resistance when standing still, and dependent on the frequency of its vibrations, and on the length of path at the contacts, as well as on the nature of the contacts. Maxwell suggested, and Mr. Glazebrook has used, a method for measuring the capacity of a condenser by measuring the apparent resistance of a vibrating contact apparatus, an electrically maintained tuning fork of known pitch. There is then good reason to think that a layer containing hundreds of thousands or even millions of molecules flying to and fro between its bounding surfaces will have a measurable resistance, even though the whole phenomenon be one of minute discontinuous discharges. Suppose that an interrupter like the hammer of an electric bell or the rheotome of an ordinary induction coil could be made to vibrate at a pitch higher than the highest audible sound—say, at 45,000 vibrations per second—we might measure its resistance without being able in the least to tell that it was not an ordinary resistance. It would probably vary considerably with pressure. But here we come to the question whether the entire phenomenon of elasticity is not due to incessant minute motions; a question too wide to discuss here, and itself only part of a still wider question whether all potential energy, so called, is not really kinetic energy after all.

Returning from this point to the more familiar one of the cause of the action between the two surfaces of a microphonic joint, let it be observed that there is an obvious incompleteness about both of the rough-and-ready theories which are commonly accepted, viz., that microphonic action is due (1) to the variation of resistance of the material under pressure, and (2) to the variation of the number of points of contact between the surfaces. The first view is known to be wrong; but is not the second, as thus stated, terribly imperfect? Little as we know yet about the exact kind of motion which constitutes heat in a body, we know at least this, that the heat in a solid body is a motion, vibratory, oscillatory, or rotatory of its particles. We know that the surface particles of every substance that is not at the absolute zero of temperature are animated incessantly with minute motions which are of an irregular kind not timed together, otherwise the body would emit rays of one frequency only, not all executed in the same direction at the same instant, otherwise the emitted rays would be polarised rays. We know that their average amplitudes increase, and that their average frequencies also increase, with increase of temperature; but this brings us almost, if not quite, to the boundary of present knowledge. We know, further, that the most highly polished surfaces we can obtain may be, molecularly speaking, quite rough. A ridged surface whose corrugations are less than a half-millionth of an inch in breadth is perfectly flat to all optical tests, but such ridges might contain from five hundred to two thousand rows of separate molecules. A metal surface one-millionth of an inch square may have from four to sixteen thousand molecules on its top surface. Think of two surfaces such as we have to deal with in telephonic transmitters, say one of platinum and one of carbon. Both rough, both heated by the passage of the electric current—that is to say, each having its molecules in violent agitation, and ready to discharge electricity from the surface of higher to that of lower potential. Let these two be resting lightly in what we commonly call "contact"; what a jostling of molecules, what innumerable batterings, what millions of minute electric discharges; air particles, nay, even solid dust particles torn from the two surfaces, flying to and fro betwen them, forming a veritable Crookes's layer. Then think what is the meaning of putting more pressure on to such a "contact." The thousands of molecular makes and breaks that were going on will be multiplied; the paths of the flying molecules shortened: more current will flow; heat agitations become still more energetic. Take off the pressure, the two surfaces fling one another apart, or bombard one another apart; discharge takes place more slowly; the apparent conductivity of the layer is reduced. Move the surfaces still further apart, the atomic clash and atomic bombardment is still further enfeebled. Separate them by a visible distance—like the spheroidal drop separated visibly from the hot plate beneath it—still there are the flying molecules at work between them. Will any one undertake to say that at sensible distances, such as one-thousandth of an inch, or even one-hundredth of an inch apart, no discharge takes place at all across the gap? Think of this, and then meditate on the shallowness of the dictum that when two clean platinum contacts are used in a transmitter, the current must be either wholly on or wholly off, either "made" or "broken," with a sharp transition *per saltum* between the state when the two surfaces are in perfect contact and the state when the two surfaces are not in contact at all. Think of the utter fatuity of the dictum that a transmitter cannot transmit unless the contact surfaces are "semi-conductors." The more one thinks of the matter from the point of view of the molecular vibrations, the more plain is it that every transmitter that works by varying the resistance of the circuit—every one of Class I. in the table of transmitters—works by varying the number of molecular contacts, and that the most perfect transmitter will be the one that does this in the most effective correspondence with the displacements in the air caused by the speaker's voice, and will give the effect of undulation when the air particles merely undulate, and will give the effect of intermission when there is intermission between the motions.

The foregoing considerations will perhaps make more intelligible the action of heat in assisting microphonic action. It is my opinion that what heat can do can also be done by auxiliary vibrations of such periods as shall not interfere with the tones of the voice. I have had an apparatus lately constructed to test this matter.

Intermittence in Vibrations.

It was remarked earlier in this paper that the noise commonly attributed to "make and break" is really due to sparks; and that if these are suppressed, "break" produces no more noise than "make." Under these circumstances speech is perfectly transmitted by sensitive arrangements in which otherwise the speech might be drowned by the spark-rattle. The mere fact that the vibrations corresponding to a certain sound stop for a short time does not necessarily produce on our ears any discontinuity in the sound. Nay, if, for example, the vowel "*a*" is being sounded in a telephone, the receiver at the other end will continue to emit the same sound, even though the electric impulses are occasionally interrupted. Impulses, large and small, discontinuous in themselves, if rightly timed, will suffice to set up any desired form of vibration upon a proper receiving tympanum. Take a complex sound such as that represented in the curve shown. We know that if we translate this into electric undulations of the form either B or C, we shall get the same sound reproduced in the receiver. But we also get the same complex sound by the discontinuous impulses of intermittent electric currents such as are represented graphically by D and E, provided the discontinuous impulses, large and small, are rightly timed and proportioned. To assert that discontinuous electric impulses cannot set up and maintain a continuous vibration in the armature of a telephone receiver would be as absurd as to assert that discontinuous impulses cannot set up and maintain the continuous rotation of a fly-wheel or the continuous oscillation of a swing. But it is hardly worth while to prove by argument what has been abundantly demonstrated in fact.

Materials for Transmitters.

Much time has been expended by me in endeavouring to find a pair of materials, which, when used as the contact-surfaces of a transmitter, should give better results than the ordinary contact of platinum against carbon. Contacts if made in both parts of metal are somewhat uncertain in action, chiefly because of the deterioration of surface. I have also examined many of the substances, natural and artificial, which possess quasi-metallic conductivity. Some of these form excellent materials, but each has its own particular qualities. Amongst natural minerals I have tried the following:—Native Arsenic, Mispickel, Ilmenite, Allemontite, Specular Iron Ore (black crystals), Magnetite, Micaceous Iron, Cloanthite, Pentlandite, Clausthalite, Redruthite, Chalcopyrites, Smaltine, and Pyrolusite. Some of these were better than others; but the best, micaceous iron, was difficult to obtain in workable pieces. Artificial preparations of copper treated with tellurium, and copper treated with selenium, or with mixtures of selenium and sulphur, gave results of surprising character. A hard and brittle sort of bronze formed in this way takes a brilliant polish like steel, and yields, when used against a platinum point, an articulation which for crispness far surpasses anything to be obtained from hard carbon. At one time this bronze was used for the valve pieces of the valve transmitter, but although the articulation when the ball valve was newly polished left nothing to be desired, it was found to acquire from the moisture

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of the air a film, probably of selenic acid, at the contacts, which gave rise to curious, shrill whistling sounds. Mr. G. L. Anders has made excellent transmitters of osmium and of palladium. Nickel also answers fairly well. There is a great difference between different materials with respect to the range of amplitude of vibrations suitable for them. For the metals in general the range of amplitude of motion must be very small; they require almost rigid connections. With hard carbon and with the copper-selenium composition the range is much greater. The copper-selenium composition requires a greater initial pressure at the contacts than hard carbon does. So also does chalcopyrites, which has recently been suggested by Mr. P. Rabbidge. In our present state of knowledge of the properties of those bodies which possess quasi-metallic conductivity, it is difficult to frame any explanation of these facts, or draw a useful deduction from them.

Transmitters on other Principles.

Incidentally my work has touched one other method of telephonic transmission—namely, that originated by Graham Bell. To Bell belongs the unquestioned, and I think unquestionable, honour of having suggested the magneto-electric method of transmitting, as distinguished from the contact method. But, in nine cases out of ten, where telephones are used, Bell's method is not employed, having been abandoned in favour of battery and variable contact. Even the Imperial German Post Office, which for eight years has been faithful to Bell's method, has now abandoned it, and is replacing all its magneto-electric transmitters by microphonic transmitters. My own work, which is more fully detailed under the heading "receivers," consists in devising a form of instrument on the principles, and with some of the actual parts, of the modern dynamo-electric machine. I have also succeeded in transmitting speech by an apparatus the principle of which was to use a nearly constant current, but to vary the number of times that it circulated around the primary of the transformer, by cutting out more or fewer of the coils.

Transformers.

The desirability of getting rid of sparks at the electrodes has been referred to. A shunt made of a thin resistance wire (as in Johnson's transmitter), or a liquid resistance, does not satisfactorily accomplish this end, though it mitigates the evil. I have found that the best method is to use a differentially wound transformer. My coadjutor, Mr. Jolin, had found, when experimenting on an electric meter, that a double differential winding on an electro-magnet enabled him to open and close the circuit without any appreciable spark, even when using very strong currents. On suggesting to him that a similar device might be applied to the primary coils of the transformer, the transmitter being placed in one branch, he constructed one, but found it expedient to add a balancing resistance in the other branch. The primary circuit is shown in dotted lines, dividing at A; the valve transmitter V being in one primary, and a thin German silver wire, W, as a resistance in the other. The secondary coil is in parallel with the receiver. The electro-magnet shown at M relates not to the transmitting circuit at all, but to a peculiar arrangement of receiving circuits, in which an electro-magnet (that of the call-bell) is used as an induction plug. It may be remarked in passing that this differential method of working is applicable to other transmitters; in particular with sensitively adjusted transmitters, to which one must not speak too loud, and which are affected by vibration of buildings, the articulation is immensely improved by its use. Even the Blake works excellently amongst the machinery of a factory when provided with one of the differential transformers. The "Valve" telephones are all provided with them. You may shout as loud as you please to these instruments without producing any unpleasant rattling sound. We also constructed transformers having closed magnetic circuits, but found that the increased labour of manufacture outweighed the advantage. A transformer very similar to that used in the Blake telephone, but with slightly more primary wire, has been found superior to the larger transformers used by the General Post Office in their Gower-Bell telephones. In transformers for telephonic purposes, it is desirable to have such an arrangement as shall give maximum mutual induction with minimum self-induction. As induction coils are usually constructed, it would appear that when the size is increased the mutual induction does not increase proportionally. At any rate, two small ordinary induction coils, having their primaries united in parallel and their secondaries in series, give a better result than the same of wires made up in one single induction coil of similar form. Possibly Mr. Langdon-Davies's phonopore may eventually prove the best transformer for telephonic work.

Receivers.

In the course of my work many devices for the improvement of receiving instruments have been tried. To place the subject in a clearer light, I here append a systematic table of the various classes and genera of receiving instruments.

Classification of Receivers.

I. *Electro-magnetic Force.*	
1. Magnetic expansion	Reis.
2. Electro-magnet with armature	Reis, Yeates, Varley, Gray, Bell, Macdonough, &c.
3. Two electro-magnets attracting	C. and L. Wray.
4. Electro-magnet itself vibrating	Theiler.
5. Electro-magnet altering friction	Dolbear, Cooke.
6. Solenoid and magnet	Bell, Siemens.
7. Two coils attracting or repelling	Vail, Taylor.
8. Deflection of needle by coil	Bidwell.
9. Pivoted armature near field-magnet	
10. Magnetic repulsion	
11. Two parallel wires	
II. *Electrostratic Force.*	
1. Air-condenser attraction	Wright, Varley, Dolbear.
2. Air sound from alteration of surface density of charge	(?)
3. Electrostatic repulsion	
III. *Electro-capillary Force*	A. Breguet.
IV. *Tribo-electric Force.*	
1. Physiological (increase of friction)	Gray.
2. Moist chalk against metal (decrease of friction)	Edison.
V. *Microphonic Contact Repulsion*	Berlinger, Hughes.
VI. *Thermal Expansion.*	
1. Expansion of wire by heat	Preece.
2. Glow-lamp	Dolbear.
VII. *Crookes' Tube*	Dolbear.
VIII. *Crookes' Layer.*	

With the exception of the discovery that a Crookes' layer between a "spheroidal" drop and the plate below it can act as a receiver, and that a receiver can be made to work (feebly) on the principle of electrostatic repulsion, the only work that I have to mention relates to receivers of the first class—those in which the electric current produces the motion by means of the magnetic force which it exerts. Upon the table here I have several instruments based on the principle of magnetic expansion. They all require stronger currents than the ordinary receivers. Messrs. Alabaster and Gatehouse have worked in this direction also with some success. Next I exhibit a modification of Bell's membrane electro-magnetic receiver, in which the form given to the electro-magnet is the one found to be the best for the attraction of the small disc-armature, about the size of the thumb-nail. The coil is surrounded by a circular pole-piece, cut away at one point, to hinder eddy currents; this outer pole-piece being of opposite polarity to the central pole-piece. The pull of such an electro-magnet upon its armature is powerful, and varies greatly with the thickness of the gap between the iron disc and the poles. This modified form of the membraneous receiver is an exceedingly satisfactory instrument. Its magnetism requires to be excited by a current while in use; but when used as I have been employing it, along with the "Valve" transmitter, it proves to be less sensitive to induction than most other instruments; and is, indeed, now in use on lines where, with other instruments, conversation was impossible, owing to the deluge of stray noises.

I have found that two iron wires stretched close together across a sounding-board, and traversed by the current, will answer as a receiver; but their natural note interferes with the tones of the voice. A receiver can also be made in which the working parts are two parallel iron cores which repel each other when similarly magnetised.

But my attention has been more directed of late to the object of bringing to bear on the small scale the same general principles which have been found to hold good on the larger scale in the construction of dynamo-machines and motors. Given a circuit into which the transmitting apparatus has thrown fluctuations of electromotive force of a certain amplitude, the problem is to utilise in the receiver the largest amount of the electric energy. All the principles that come into play in the electric transmission of energy come in here, but with certain restrictions. For example, not only must a certain amount of electric energy be transformed into mechanical energy in order to give the sound of the required loudness, but the mechanism must be such that the organ which emits the sounds, be it a tongue or a tympanum, or any other organ, must be capable of moving with large amplitudes or small, with rapid frequencies or slow, and must still in moving generate such counter electromotive forces as shall make the work utilised a maximum. All such principles of construction as apply in dynamos to the avoidance of eddy currents, of needless self-induction, of magnetic leakage, and the like, also apply to the receiving telephone. There is a conductor which carries a current, there is a magnetic field in which the conductor lies. Either the conductor, or else the field-magnet, or some part of it, must move, and it is desired to make their mutual reaction as great possible. If the coil is to move it must be placed in the strongest possible field, and so placed that its minimum motion shall alter by a maximum amount the total magnetic induction through it. The iron or steel should be arranged so that the magnetic circuit which they form should be as nearly closed on itself as possible. By the light of dynamo principles it is simply absurd to construct a receiver in which one pole of the magnet is far away from the working parts. Furthermore, just as in every dynamo and motor there is a gap or gaps in the magnetic circuit where the working coils are situated, so in telephonic receivers there are gaps in the magnetic circuits, and it is there that the working coils should be situated. Take any one of the modern improved receivers—those of Siemens, Gower, Ader, d'Arsonval, Ochorowicz—their magnetic circuit is all but closed, and the coils are *at* the gaps. It is there that their currents in passing through a given fluctuation will produce the greatest effect on the magnetism of the magnetic circuit, and therefore on the attraction between the two parts. The current must be brought to bear, so to speak, upon a loose-joint in the magnetic circuit.

There is another matter in which our present knowledge is very imperfect. It is found that in every receiver (even the electrostatic ones too) there must be an initial force exerted upon the vibrating part, be it tongue or tympanum, or any other kind. A mere unexcited electro-magnet placed behind an iron diaphragm is practically useless to receive alternating currents from the secondary coil of a transformer. It does not speak out until its core has received an initial magnetism

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either from an initial current or from an auxiliary magnet, permanent or temporary. No doubt a portion of this effect is purely mechanical, for the same reason that an acoustic telephone does not speak properly unless the line between its two tympanums is taut. Moreover, as Mr. Giltay has shown, a non-polarised core, excited by an alternating current, would give rise to double the proper number of vibrations—would raise the pitch an octave. But there is more than this, and it requires further investigation. Consider the diagram, which represents a cycle of magnetising operations such as we have become familiar with from the researches of Dr. J. Hopkinson and of Prof. Ewing. We know that if we first of all decrease the magnetising current by a certain amount, δi, and then increase it again by an equal amount, we shall carry the magnetism down and up again along a small cycle. Three complete small cycles are represented in the figure. Now one would have expected that one would get the greatest variation in magnetism for a given variation of current at that part of the diagram where the curves are steepest, where the ratio $\delta M/\delta i$ is greatest. That is to say, one would expect the iron core to be most sensitive to current fluctuations when there was no initial magnetism, and least sensitive where there was great initial magnetisation. But experience, not with telephonic receivers only, but with polarised relays, tells us that this is not true where time comes into account, and that if we make the current fluctuate *rapidly*, we get the greatest magnetic fluctuations when there is some initial magnetisation. Some experiments of mine now in progress go to show that the "sensitiveness" of the iron core increases with an increase of initial magnetisation, at first slowly, then more rapidly, and has not attained a maximum even though the magnetisation be pushed far beyond the bend of the curve of magnetisation. But there are some obscure contradictory facts still requiring explanation. In view of the fact that an initial magnetisation is needful to make a receiver respond properly, it appears to me that an absurd amount of importance has been attached to the disputed discovery that a permanent magnet might provide this initial magnetisation instead of a permanent current. No doubt it was surprising to learn that a transmitter could transmit without employing a battery; but as this method of transmitting has been practically abandoned, the importance of the discovery vanishes with it. There is no novelty whatever in using a mere polarised receiver.

It now only remains for me to describe briefly three forms of receiving instruments in which some of these ideas are embodied. Examples of most of them are on the table, and they are illustrated by the remaining figures.

Another form of instrument is named a "Spring" receiver. It is based upon the early form of C. and L. Wray, in which two electro-magnet cores attract one another, and so impart motion to a sounding-board. In my instrument the sounding-board is replaced by a flat spring, P, of mica, ebonite, or some non-magnetic metal, to which are attached the two working cores C_1 C. These form part of the magnetic circuit of an external magnet, N S, and the working coil E is placed over the gap in the magnetic circuit. Iron or steel, if used for the spring, would spoil the action, as it would short-circuit the magnetism. This receiver works extremely well on induction circuits. An important point in its design is that the centre of the spring, which will have the greatest amplitude of motion and is most active in imparting sound to the air, is not under a perpetual magnetic constraint like the central part of the iron diaphragm of the common telephone receiver.

A form of receiver was next mentioned in which the magnet is a long narrow triangle of steel, having the apex bent round and inserted in a circular cavity cut out in the base of the triangle. The south pole thus surrounds the north, and in the intervening gap lies the working coil. Instead of the usual iron plate held down all round there is a metal cup, or dish of metal, ebonite or celluloid, which can be held over the ear, and it is held up at its centre by being riveted by a stout iron rivet to a short triangular steel spring. This instrument, even in a crude form, is excellent both as receiver and transmitter.

This form of instrument I have ventured to term a "*Dynamo-telephone*," inasmuch as the action of these instruments is directly taken from that of the modern dynamo. The parts are distinctly differentiated into a field-magnet, which stands still and furnishes an intense magnetic field, and an armarure whose coils are traversed by the working currents. The main point of difference is that, whereas in the dynamo-electric machine, whether used as generator or as motor, the armature rotates, in the dynamo-telephone, whether used as transmitter or receiver, the armature merely vibrates, being pivoted elastically. It is represented in the drawings as being connected to a diaphragm, D. Of other forms of instrument which are not yet out of the laboratory stage I must not speak.

In conclusion, I would reiterate my conviction that the success of long-range telephony depends upon the possibility of devising instruments which, on the one hand, can be used with higher battery power to transmit stronger currents, and which, on the other hand, will be adapted to receive these currents by means of apparatus which, though not necessarily more sensitive to small currents than the previous receivers, will have a higher electrical and mechanical efficiency. And I am convinced that the path of progress lies very near the road already travelled by those who have perfected the existing machinery for the electric transmission of power.

DISCUSSION.

Mr. W. H. PREECE utterly dissented from many of the views expressed in the above paper, more especially with that which contemplated solving the telephonic difficulty by employing strong currents with less sensitive receivers. The real solution rests with the wire and not with the apparatus. This was his deliberate conclusion after ten years' experience and experiments on all kinds of lines and with every known instrument. For perfect working the line must be free from electro-static and electro-magnetic induction, and, given such a line, the kind of telephone attached to it was of small importance. The other day he experimented at Worcester with a line of copper wire passing through there from London to North Wales. This wire, except for a very short distance, is separate from the other wires along the same route, and is practically isolated for a distance of 270 miles. He found that telephoning to London with such a wire was clearer and louder than telephoning within the area of the metropolis. The sibillants were good, and whistling was perfect. On this line Bell's original magneto instrument acted admirably; whereas when we put that or any other instrument of the kind on half a mile of ordinary wire under the prevailing conditions speaking is impossible. Mr. Preece also took exception to Prof. Thompson's version of history in regard to this subject. He was unjust to Graham Bell, for example, in coupling his name with Reis. It was ungenerous to compare Bell's and Hughes' discoveries with those of men who were only playing with a toy. Previous to Sir W. Thomson bringing news of Graham Bell's discoveries to this country, nobody in Europe had conceived the possibility of electrically transmitting articulate speech. The same injustice, he thought, was done to Van Rysselberghe, whose great service was to render ordinary working telegraph wires available for telephonic purposes as well. Speaking generally, inventions such as those laid before the meeting by Prof. Thompson started by creating imaginary difficulties which the inventors then set about overcoming. Their real object seemed rather to be to evade existing patents; and when all was said, they had to come back to some form of the Hughes microphone.

The discussion was here adjourned, Mr. Preece reserving his concluding remarks for the next meeting.

LEGAL INTELLIGENCE.

The Edison and Swan Electric Light Company v. Woodhouse and Rawson.

Lords Justices COTTON and FRY delivered judgment in this case on Monday morning. It will be remembered that it was an appeal against the judgment of Mr. Justice Butt, in an action against the defendants, arising out of an alleged infringement of three patents taken out by Mr. Swan, Mr. Edison, and Mr. Gimningham.

Lord Justice FRY said: By the request of Lord Justice Bowen, I am about to read, in the first place, the judgment of Lord Justice Bowen and myself, and not that of Lord Justice Cotton. The plaintiffs in this action are the assignees of letters patent, dated Nov. 10th, 1879, and granted to Mr. Edison for the invention of and improvements in electric lamps, and in the method of manufacturing the same. The defendants are manufacturers of electric lamps, and are sued for an infringement of the patent. Mr. Edison's object, as stated in his specification, was to produce electric lamps, giving light by incandescence, which lamps should have high resistance, so as to allow of the practical subdivision of the electric light. Mr. Edison, in his specification, proceeds to state of what his invention consists. The first element in his invention is the coiling or arranging a light-giving body of carbon, wire, or sheets, so as to make the resistance high in proportion to the light-giving surface. The second element was the placing of the light-giving body in a nearly perfect vacuum. The third element was the conducting of the current into the vacuum bulb through platina wires sealed into the glass. The fourth element was the mode of manufacturing carbon conductors. The fifth element was the mode of securing perfect contact between the metallic wires and the carbon. After some statements as to the existing state of knowledge and invention the patentee proceeds in his specification to describe the mode of carrying his invention into effect. The description is so far from being as clear as it might be that we at one time doubted whether it was not studiously and wilfully obscure, but on further consideration we are not prepared to hold such to have been the case, especially as the point was not urged by the appellants. It is not needful for us to pursue the description of all the processes given by the specification; but we will refer to the forms of carbon conductor described. The first form referred to as suitable is "cotton thread properly carbonised," which is stated to offer from 100 to 500 ohms resistance to the passage of a current. The second form of conductor referred to is any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber. To this class may be referred the "cotton and linen thread, wood splints, and paper coiled in various ways," to which Mr. Edison refers. The fourth form is "such fibrous material as before mentioned rubbed with a plastic compound of blacklead and tar." The fifth form is a carbon filament made of a combination of tar and lampblack or plumbago, or carbon in other forms, the tar being subsequently carbonised by being subjected to high heat in a closed chamber. (Page 4 of specification, lines 1—40.) Mr. Edison observes that small pieces of such a compound may be rolled out in the form of a wire as small as $\frac{7}{1000}$th of an inch in diameter. The sixth and last form described is a carbon filament of the kind lastly described, but coated for the purpose of support with a non-conducting, non-carbonising substance. By his specification Mr. Edison makes four claims, namely: (1) An electric lamp for giving light by incandescence consisting of a filament of carbon of high resistance made as described and secured to metallic wires as set forth. (2) The combination of a carbon filament within a receiver made entirely of glass through which the leading wires pass and from which receiver the air is exhausted for the purposes set forth. (3) A coiled carbon filament

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or strip in such a manner that only a portion of the surface of such carbon conductor shall radiate light as set forth. (4) The method herein described of securing the platina contact wires to the carbon filament and carbonising of the whole in a closed chamber substantially as set forth. The first claim I understand to be for the entire lamp—that is, for all the elements of the invention brought together in one combination. It is conceded by the plaintiffs that the defendants have not used this entire combination, and secondly, that there is no infringement of the first claim. The second claim is the one on which the real trouble arises, and it is necessary in the first place to ascertain its true construction. To us it has been extremely difficult to follow the learned counsel for the plaintiffs in the interpretation which they have presented in respect of this claim, because these interpretations have seemed to us not only to vary, but to be too vague. But in our opinion this claim ought to be construed with all the generality which its words seem to convey, so that it may be paraphrased as a claim to every combination of any carbon filament with any receiver made entirely of glass, through which any leading wires pass, and from which the air is exhausted. The words "for the purposes set forth" at the end of the claim may cover either the whole claim or qualify the antecedent word "exhausted." In the former case it described the exhaustion of the receiver as introduced for the purpose of preventing alike chemical and mechanical destruction from the presence of any gas—a purpose which Mr. Edison has enunciated and explained in the course of his specification. In this view the first claim differs from the next in not embracing the coiling or other similar arrangement which is the first element of the investigation, nor the use of platina as distinguished from other leading wires, nor the mode of attaching the metallic to the carbon conductor. But the second claim embraces a combination of the five elements following, namely—(1) a carbon conductor; (2) in the form of a filament; (3) a receiver wholly of glass; (4) a vacuum; (5) the entrance of the leading wires through a glass receiver. The third claim is for that peculiar arrangement for coiling or similar process by which a portion only of the carbon conductor radiates light. The fourth claim is for the attachment of platina contact wires to the carbon filament and the carbonising of the whole in a closed chamber, so that the third and fourth claims are those very portions of the entire combination which are not in the second claim, or, in other words, the entire combination. The subject of the first claim is subdivided into three subordinate parts or combinations, the subjects of the second and third and fourth claims. It is satisfactory to find that the wide construction of the second claim was fully present to the minds of the counsel for the defendants when conducting the case in the Court below, so that in adopting that construction we are not running any risk of departing from the lines on which the case was fought in the first instance. There was distinct evidence of the utility of the combination contained in the second claim, not, so far as was shown us, met by any opposing evidence. Indeed the utility of the patent, and consequently of everything actually claimed by it, is not in dispute. Furthermore, it is not denied that upon the interpretation we have placed upon claim 2 the defendants have infringed it The lamp, W. and R., which was the subject of admission in the case, appears to us to be clearly an instrument made in accordance with the claim in question—it is a combination of a filament admitted to be carbon with a glass receiver, admitted to embrace a vacuum, and with conducting wires passing through the glass. But, then, it is said by the defendants that the patent is wanting in novelty. It is not, indeed, contended that the entire combinaton of claim No. 1, or the subordinate combination of claim No. 4 has been anticipated, but it is urged that the combinations claimed in claims 2 and 3, according to the true reading of them, are not novel; that if novel the second claim is expressed with a vagueness which is fatal to its validity, and that what was new in that claim is not a good subject of a patent. What, then, was the state of public knowledge on this subject when the patent of November, 1879, was granted? It was perfectly well known that light was to be produced in an electromotive current by resistance in a conductor. It was further known that resistance depended on four conditions or factors, namely, 1st, temperature—a matter which, as it has not been brought into consideration in this inquiry, we may for the future disregard; 2nd, the specific resistance of the matter of which the conductor is formed; 3rd, the length of the conductor; and, 4th, its sectional area. Furthermore, it was shown that from 1845 and downwards various attempts had been made to introduce incandescent electric lamps, but there is no evidence that any such lamp had been made with the exception of two which had been constructed and exhibited by Mr. Swan. With regard to the lamp said to have been made by Mr. Justice Grove in 1843, no evidence has been given to us. The problem before Mr. Edison was to find some conductor in which he could obtain high resistance to the current with greater durability—that is to say, great capacity to resist disintegration by heat, and the absence of all disintegrating influence of any gas, whether such influence were chemical or mechanical. The high resistance he might obtain from any use of the three factors already referred to, the specific resistance or length of the conductor, or its sectional area. As we have already seen, Mr. Edison satisfied the conditions of this problem by using carbon, a substance of low conductivity, in a form in which the length of the conductor was great in proportion to its sectional area, and by placing this conductor in a chamber not occupied by an inert gas like nitrogen, but by a vacuum as complete as is obtainable. The importance of this combination can hardly be doubted, for, if not alone, yet in combination with other improvements it has had this result, that, whereas before November, 1879, two or three experimental lamps were all that had been produced, after that date such lamps had been produced by tens of thousands, and constitute a most important element in our methods of lighting. In what ways did the alleged anticipations of Mr. Edison attempt to accomplish incandescent lighting? This point we shall first investigate with regard to the second claim. The first specification to which our attention has been called is that of King, in 1845. He proposed the use of two kinds of conductors, metallic and carbon. The metallic conductor (for which purpose he proposed platinum) was to be made incandescent in the air. The carbon conductor was to be used in a space from which air and moisture were excluded. "To accomplish this," says the patentee, "in the most perfect manner it should be enclosed in a Torricellian vacuum." So far as Edison uses carbon in the vacuum King was evidently in anticipation of him. It becomes necessary, therefore, to consider with some exactitude how King proposed to give effect to this portion of his invention. He explains one form of the apparatus only. This consists of a barometer tube and column, but with the upper portion of the glass tube enlarged so as to contain in it the light-giving apparatus, which consisted of a piece of carbon of the kind found in the interior of coal gas retorts formed into a small pencil or thin plate, but of a width, as shown in the diagrams, greatly exceeding that of the conducting wires. The circuit was to be made beginning at the upper end, by means of—first, a platinum wire sealed through the glass; second, a piece of iron, *d*; third, the forceps attached to the iron and to the carbon; fourth, the carbon; fifth, similar forceps; sixth, a similar piece of iron; and then, seventh, the mercury in the tube, or when this was depressed by the formation of vapour of mercury, a copper wire passing from the lower piece of iron through the mercury column. Now, comparing this apparatus with the combination embodied in the second claim of Mr. Edison, we find a carbon conductor and a vacuum; but we find that the carbon was not required to be a filament—we find that it was to be placed in a receiver made, not entirely of glass, but partly of glass and partly of the top of the mercury column; consequently that the leading wires were to pass, one through the glass and one through the mercury. Roberts comes next with letters patent bearing date 1852. This specification dealt with a wide range of the applications of electricity, and it is only a small part of his specification which at present demands attention. Roberts proposed to obtain electric light by passing a current through a thin piece of graphite, coke, or charcoal, or other infusible body being a conductor of electricity while it was enclosed in a vacuum not containing any oxygen or other matter which could cause the combustion or destruction of it. The apparatus by which he proposed to effectuate this object consisted (1) of a glass globe fitted with a metallic cap turned on its outside as a screw; (2) a hollow pedestal furnished at the top with a collar, into which the metallic base of the globe is screwed; (3) a tube furnished with an appropriate stop-cock passing up the hollow pedestal; (4) a piece of very thin graphite, about half an inch long, half an inch wide, and as thin as might be, suspended in the globe between two metallic rods. The tube passing through the pedestal served two purposes; in the first place it was the means by which an air pump or exhausting syringe was used to free the globe of air, and in the next place it formed part of the line of electric communication, for in this instrument the current passes from the battery along this tube, then along one of the metallic supporting rods, then along the graphite, then down the other supporting rod, which passed through the metallic cap of the glass globe, but was kept from metallic contact with it by ivory or other non-conductor. Now, comparing this apparatus with the second claim of Mr. Edison, we find that it differed in that Mr. Roberts did not use carbon as his sole material, that he was content with the exclusion of gases chemically destructive, and was not alive to the importance of the mechanically destructive action of gases; that his receiver was not made entirely of glass, and that the leading wires did not pass through glass, but through the metallic cap of the receiver. In 1874 or 1875 the Sprengel pump was brought into use, and gave a great stimulus to all investigations into operations carried on in vacuo, and amongst others to electric lighting in vacuo. Mr. Lane-Fox's specification of October 9th, 1878 (No. 3988), is the first that demands attention. This invention consisted in passing an electromotive current through a thin strip of wire of some suitable material. Mr. Fox preferred an alloy of platinum and iridium. In order to prevent the deterioration of the material when incandescent, Mr. Fox states that he sometimes surrounds it with an atmosphere of nitrogen gas. That Mr. Fox's lamp had a great general similarity to the one now in use cannot be doubted; but the most suitable material known to him, and the only one he mentions, is an alloy of platinum and iridium, metals which, though of low conductivity as compared with many other metals, have a high conductivity as compared with carbon. He did not regard inclusion in a glass or any receiver as necessary, and when he did use such a thing he filled it with nitrogen gas. We have not carbon in the filament, not the glass receiver, and not the vacuum of Mr. Edison. In Mr. Fox's next patent, dated Oct 12, 1878 (No. 4043) he proposed the combination of non-conductors with conducting substances. In the first form he retained his wires or strips of metal (preferably the alloy of platinum and iridium), but he coated them with an earthy non-conducting material such as lime, because at a given temperature they seemed to radiate or give off more luminous rays in proportion to the non-luminous rays than the platinum-iridium wire at the same temperature. In his second form of conductor he employed asbestos, or some other non-conducting refractory material, saturated or impregnated with a conducting body such as carbon or iridium. In whichever of the two ways the conductor was constructed it was to be placed in a glass flask, hermetically sealed, and filled with nitrogen gas. It is obvious that in the first form of conductor we have a metal and not a carbon conductor; in the second the resistance is raised, not by the reducing the carbon to a filament, but by the intermixture of a non-conducting material with a conducting one, or by the sub-division and extenuation of the conducting material by the mode of its application to the non-conductor. We miss, too, the vacuum which was to protect the conductor from all mechanical deterioration. In short, we have not the carbon filament nor the exhausted receiver of Edison. A few days after the two patents of Mr. Lane-Fox, a patent was granted to Mr. Van Choate (October 31st, 1878, No. 4388), in respect of which he deposited

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a provisional specification only. The material to be employed by this inventor is vaguely described as "composed or formed of asbestos, mica, platinum or carbon, or any combination of them and such other materials as may be required to give the proper affinity and homogeneity to the material." It is evident that this is no adequate description to enable anyone, without further experiment, to ascertain of what the conductor is to be made or of what form it is to be. In the following month the industry of Mr. Lane-Fox resulted in his third patent (November 14th, 1878, No. 4626). The point here relied upon by the appellants was the description of the conductor contained in the provisional specification. But, in our opinion, this was nothing other than a repetition of the second form of conductor described in Mr. Fox's specification to his patent of October 12th, and not then filed. There is no new light thrown on the inquiry by this provisional specification. In the same month of November, 1878, letters patent were granted to Mr. Pulvermacher (November 23rd, 1878, No. 4774). This invention was intended for use in an arc lamp, and though referred to for other purposes, it was not urged upon us that it contained any anticipation or combination contained in the second claim. Next comes Mr. Lane-Fox's provisional specification of March 20th, 1879 (No. 1122), which proposed to construct the incandescent portion of a conductor by a mixture or combination of two highly refractory materials, one being a conductor, such, for example, as plumbago, and the other of non-conducting or badly conducting material, such as magnesia, zirconia lime, steteatite or earthy matter, and he directed that the non-conducting material should be considerably in excess of the conducting material. The conductor was to be enclosed in a globe from which not all gas, but, as we read the specification, any gas or matter capable of effecting a chemical change in the luminous bridge should be removed. It is evident that here we have neither the carbon conductor for the filamentous form, nor the vacuum of Mr. Edison. There is no evidence that a single lamp made under any one of the specifications or provisional specifications we have referred to ever gave a ray of light. The rapidity with which the patents succeeded one another in 1878 and 1879 shows how keen was the race for the production of a good incandescent electric light, and the fact that no one of the inventors in question is shown ever to have succeeded, seems to be strong evidence that every one of the ingenious apparatus which they devised resulted in failure. On the 19th December, 1878, Mr. Swan, one of the present plaintiffs, exhibited to the Newcastle-upon-Tyne Chemical Society a lamp constructed entirely of glass, containing in vacuo platina leading wires hermetically sealed into a glass, between which wires was suspended a rod or pencil of carbon, slender, but not so slender as to be described as a filament. This produced incandescent light for a while, and then the carbon rod bent or bulged downwards, in consequence, as it appears, of the electromotive force being too great for the cylinder of carbon, and the inner side of the glass was lined with a sooty deposit, which on examination proved to consist of platinum, carbon, and iron. On the 3rd February, 1879, Mr. Swan, in the course of a lecture to the Literary and Philosophical Society of Newcastle, exhibited a second lamp of the same construction, which gave out a very considerable incandescent light for some twenty minutes. It has been on exhibition in this cause, and appears, like the first lamp, to have become to some extent coated on the inner surface with a dark deposit. On the 12th March, 1879, Mr. Swan again described his lamp to a Gateshead audience, but it does not appear that he exhibited it, and from that time it has, so far as this case is concerned, disappeared from history, and this disappearance is, we think, cogent evidence that Swan's lamp, as it was exhibited, was not a practical success, that Swan could not do what Edison did, and that the difference between a carbon rod and a carbon filament was the difference between failure and success. The result of this review of all the alleged anticipations of the second claim is to convince us that there was no case in which there were brought together all the five elements which we have pointed out as combined in Mr. Edison's second claim—carbon in a filamentous form in a vacuo and in a receiver entirely of glass through which the leading wires pass. But as between Swan and Edison the difference is only between a rod and a filament—that is, a difference of degree and of degree only. Mr. Edison has in his specification given no definition of a filament, and he has nowhere drawn the line between it and a rod. The specification is therefore itself argued bad, as being too indefinite and vague. To this argument it may, in our opinion, be properly replied that in a patent of this description the definition is required only to such an extent as would enable a practical workman to construct the required apparatus, that there is distinct evidence that such a workman could make the required apparatus from the specification, that no witness of the defendants alleges that such a workman would have any difficulty, or would require any further experiments, and that the specification itself, as we have already shown, contains descriptions of six forms of filament, and those descriptions, it is obvious, would afford material assistance to any workman in doubt. It is urged that a mere variation in the size of a part of the lamp is not the subject of a patent. It may well be that no patent could be sustained for the use of a filament of carbon alone, but when that filament is part of a combination which is useful, and replaces a rod in an earlier apparatus, which was useless, we can see no reason why the new useful combination may not be the good subject of the patent. It was strongly argued that the mere change of the size of a part of the combination cannot constitute a new manufacture so as to be the subject of a patent. In most instances this may be true, but the present case is peculiar. Two—and, so far as we had learned, only two—specimens of the earlier form of the instrument had been constructed, and in both of those a rod, and not a filament, of carbon had been adopted. Mr. Edison used the filament instead of the rod for a definite purpose, and by the diminution of the sectional area made a physical law subserve the end he had in view. The smallness of size, therefore, was no casual matter, but was intended to bring about, and did bring about, a result which the rod could never produce, and so converted failure into success. The point upon which Mr. Edison's instrument departed from Mr. Swan's was crucial, and the departure though slight had all the merits of a new invention, and produced a new apparatus. Three cases were cited to show us that a mere variation in the size of the carbon conductor will not constitute the good subject of a patent. The first was Kay *v.* Marshall (8 Cl. and Fin.), where the improvement claimed consisted in placing two rollers nearer to each other than they were previously used; but in practice before the patent, the distance between these rollers had been raised according to the fibre of the substance to be spun. The invention, therefore, was for the use of a well-known machine in a manner in which it could have been previously used. To grant letters patent for such an invention would have deprived the public of the means of using a machine which they had previously enjoyed. In Ralston *v.* Smith (11 House of Lords Cases 223) the patentee claimed to have invented improvements in embossing and finishing woven fabrics and in the machinery employed therein, and the House of Lords held in substance that all that was described in the specification was a new use of an old machine, and that this was not a new manufacture within the statute. In Patterson *v.* the Gas Light Company, Limited (II. Chancery Division, 812) the Court of Appeal held that the invention claimed was only an invention for the more beneficial working of an old process, and that this was not a new manufacture. It does not appear to us that any of these decisions show or tend to show that the introduction into an old combination of a new shape of one of the old elements of that combination which invokes a law of nature, otherwise left on one side, may not be the good subject of a patent. For these reasons we are of opinion that the objection to the second claim fails. With regard to the third claim, which relates to the peculiar arrangement adopted by Mr. Edison by which he reduced the light-giving surface of the carbon in proportion to its length, it was contended that this was anticipated by the publication of the specifications of Van Choate and Pulvermacher. Van Choate, it will be remembered, proposed to employ a substance composed or formed of asbestos, mica, platinum, or carbon, or any combination of them, and such other materials as might be required to give the proper affinity and homogeneousness to the material. This substance, he further says, was preferably made into wire or ribbon, and formed into arcs, spirals, or spiral globe-shaped illuminators or burners, or the material might be formed into discs or globes, or spirals wound round a central wire or body, or into other shapes required to form the light. It is obvious that the purposes for which Edison uses a coil, namely, the diminution of the radiating surface, and the raising of the specific heat of the whole, were not only absent from the mind of Van Choate, but would not result from large spirals, which are manifestly within his provisional specification. In Pulvermacher's invention a spiral or screw-shaped rod was used, but this was for the purpose of illumination, not by incandescence, but by the voltaic arc, and consequently it had no real relation to the coil of Mr. Edison's lamp. For these reasons we are of opinion that the third claim was not anticipated. In the result the appeal, in our judgment, fails.

Lord Justice COTTON: I am unable to agree with that which is the judgment of Lord Justice Bowen and Lord Justice Fry; and I differ from them principally on the question of the construction of this specification. Of course, differing from them as I do as regards the construction of this specification, I should say that if I agreed with them I should differ from them, as I shall hereafter point out, as to the effect of Swan's lamp. The question turns on claims 2 and 3 really, because those are the points on which it is said there has been an anticipation. As regards claim 3, I put that aside, because I agree with Lord Justice Bowen and Lord Justice Fry that Van Choate's is no anticipation of the spiral described in this specification. But the question then comes in as to the second claim, and I shall confine myself to that, but for this, that the construction put by the other Lord Justices on the first claim, in my opinion, has an effect, and an erroneous effect, on the true construction of claim No. 2. The only question arises as regards the second claim; but then to construe that properly we must see what is the proper construction of the previous patent. Lord Justice Fry has said that, in the opinion of himself and Lord Justice Bowen, that is a description of the whole combination which is described in the previous part of the specification. In my opinion that is erroneous; I cannot agree with that. What are the words of it? "I claim as my invention an electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance made as described, and secured to metallic wires as set forth." Now, that entirely omits the globe, which was to be a vacuum, and, in my opinion, is confined to that which he has previously said is part of the invention, and the material part of it—that is to say, constructing a filament of high resistance, as described, and securing that to metallic wires, as set forth. In my opinion, although if this was well drafted it would be proper as a matter of good drafting to put the whole combination either first or last, yet there is that first claim simply a claim to the incandescent portion of the lamp. He calls it lamp, but he means the incandescent portion of it, consisting of a filament made as described, and secured as described to metallic wires. There is nothing about a vacuum, and nothing about the glass globe in which this was to be. I may mention that when he describes how it is to be made, he first of all connects his filament with the wires, and then he puts that, after it is so constructed, into the globe, from which he exhausts the air. I mention my difference from them on that point because I think that rather leads them to the view which they take of this second claim. If the whole combination had been claimed beforehand, you might expect the second to be something different; but the second is clearly and simply a claim to a combination. What is it? A combination of a carbon filament within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted for the purposes set forth. Now, my only difference from them is as regards what there is meant by a carbon filament. Their view is that that means anything which can be called a carbon filament. Now, I differ from that. What is the general purpose and object of a

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claim? Its general purpose and object is that a patentee may show how much of that which he has described in his specification he claims as protected by his patent. It must be construed in my opinion with reference to that which he has already stated in his specification when he is defining the invention for which he has taken out a patent, and how the invention may be carried into effect. As a general rule the object is to say, "Notwithstanding what I have described, all that I claim is," so and so, and to limit, therefore, his claim to a certain portion of that which he has previously referred to in describing his invention. It may be, and frequently is, that where a patentee has described in his specification a certain particular mode of carrying into effect his invention, as in this case, what he says about filaments he there says: "Now, mind, although I have only mentioned beforehand certain specific forms of that which I call a filament, yet I claim everything which can be called a filament, and the combination of that with the other portions which I have described before." But here that has not been done. It is only the combination of a carbon filament. Would it be right, if we are to construe this fairly, to say, without reference to what the consequence may be, that he here claims the combination of anything which may be called a carbon filament with the other portions of his lamp. We must remember that at this time filament, as applied to electric lamps, was not a well-defined or known term. It is used, I agree, especially in the account we have had of Sidot's process; the word was used and it was not a new word. It was certainly used in botany, and although it was stated by the Attorney General that this was a word of art employed at the time when this specification was filed, there was no evidence to show that it was. Here is the difficulty in this case, as there must be in all cases where strides are made in the knowledge with reference to a particular matter, in separating knowledge at the time of the specification from the knowledge which exists in the minds of the witnesses and others at the time when the matter comes before the Court. The only way really of testing it is, looking at the knowledge at the time of the invention, and there what we find is this, that this filament—in my opinion—was not a word which had been defined in its application with reference to this matter at the time of the invention. When we come to one of the witnesses, Dr. Hopkinson tells us that it is a question of degree to decide where filament begins and where it ends. If this is to be in everything which is a filament, everything which is long and with the sectional area very small, then, in my opinion, there would be a great many difficulties as regards the validity of this patent. In the first place if that was so, and filament only depends on a question of degree, not to be fixed as commencing and ending at any particular point, I cannot see how Swan's lamp was not an anticipation. There was a lamp with the exhausted receiver and a piece of carbon connecting the two wires which brought and took away the electric current, which made it part of the circuit, and thereby its greater resistance produced the light; it was a small sectional area, though certainly not such a sectional area as was used by either the plaintiffs or the defendants. But here, if this is to be applied to every filament, there being no particular mode of combination pointed out, as I put it to Mr. Aston during the argument, "Would you say that if this combination is used, it matters not whether the filament is straight, or whether it is curved, or whether it is wound into a spiral?" He answered, "Yes, I think it would." That being so, to my mind, if the construction, having regard to the indefinite use of the word filament (I am using it with reference to it being a mere matter of degree), then I should say that Swan's, which was not a mere unsuccessful experiment, but which produced a lamp which burnt without intermission and with good effect—the second lamp, I mean, because the first was spoiled in consequence of the current of electricity being too large—I should say, taking the construction which was put upon these words by the other Lords Justices, that would be an anticipation of Edison's second claim. But that would not be the only difficulty. If that were the necessary construction of that, it is unnecessary to give a definite opinion upon it, because, in my opinion, it is not the true construction. I should have great difficulty in dealing with the objection to this patent, that it is so vague and indefinite as to be bad; and I will mention here that I am not impressed, as the other Lords Justices seem to be, by the evidence of the witnesses, that no competent workman would have a difficulty in carrying into effect Edison's invention. What they are referring to is the description given in the previous part of the specification, where he does disclose a mode of carrying into effect his invention, and no doubt the evidence is, having regard to that, and looking to these filaments there described, that no workman would have difficulty in carrying it into effect; but they do not say that if this were to be applied to every filament then the workman would have known what was meant by the word filament—would have known at or shortly after the time of this specification—or that he would be free from difficulty, and be able to carry it into effect without experiment. Really the questions are different. Then what is the claim? What is the invention for which protection is claimed? With reference to that we must not look to see how far a workman would have any difficulty in working a previous description, but whether that claim is confined to that which is previously described, or whether it launches out into a variety of other pieces of carbon which are not therein referred to, and, in my opinion, construing, as I think one ought to do, the second claim with reference to the previous specification and not applying it to everything which can be called a carbon filament, I think one ought to refer it back to that which has been referred to in the previous part of his specification as a filament, and one finds that in the beginning he speaks of carbon wires or sheets, "The invention consists in a light-giving body of carbon wire or sheets." And then he goes on with the coiling. On page 4 he refers to a filament as sometimes a wire and sometimes a thread, and in my opinion the proper and true construction of this second claim is a combination of a carbon filament, in substance such as is hereinbefore mentioned, with other matters which he refers to in his combination. The whole of that second claim is very badly drafted, because it is the combination of a carbon filament within a receiver made entirely of glass—that is, the combination of a carbon filament with nothing, only in a receiver; but I take it the true construction, construing it fairly, is that it is the combination of a carbon filament with a receiver made entirely of glass. Then, I come to the question, What is the result? And, in my opinion, the construction that I put on this specification establishes the validity of the patent—that is to say, prevents it from being held invalid either from vagueness or anticipation. But what is the result? Has there really been any infringement? There is a carbon filament undoubtedly in the lamp of the defendants. But, now, what is the essential part of a carbon filament as hereinbefore mentioned in the specification? In my opinion—and it was hardly contested—it was not confined to a carbon filament used exactly as described, and the judge held that there was no evidence that that had been done. The words are "as described"; the description is of a particular way or particular ways of making carbon filaments, and really in the specification the greatest stress is laid on the coil or the spiral, so as to have a long filament of very minute sectional area. But what Mr. Aston said was this, that a filament necessarily implied flexibility and resilience. Now, I cannot find that at all in the specification, and of course we must look to the specification in order to see whether the filament such as is mentioned necessarily involves that flexibility and resilience. Flexibility, in my opinion, is contrary to the specification. There must be flexibility before it is carbonised; but we have to deal with the carbon filament after it it is carbonised. There is nothing in the specification which requires the flexibility, or, as far I can see, the resilience. But the Attorney-General, although contending for a more general sense of carbon filament in the second claim, said that it is every filament, subject to this restriction or qualification—if he put any—that it must be made into a filament before it is carbonised. At first I thought that there was nothing in the specification which would lead to that conclusion; but on looking carefully at it, it appears to me highly probable that the essential part of what he described in this specification as filament was that it should be made into a filament—that is to say, into a fine wire or thread—or exist as a fine wire or thread before it was carbonised; and there are a great many passages in the specification—which is the only thing one would look to to rely on in a matter of construction—which will lead to that conclusion, because I find this on page 4. He describes how to make a very fine wire out of some plastic material, and then he shows how that is to be formed into a spiral; then he says on line 8, "The spiral after carbonisation retains its form." Then he says what may be done to prevent the bit of wire which he has wound cracking during the process of carbonisation. It cannot be afterwards, because he says, "I sometimes roll a thread within the compound of lampblack and tar so as to allow of greater convenience in handling the same." That must be before it is carbonised. "The flexible carbon filament is not so liable to crack by its own weight in the act of winding." It is not to be wound after the carbonisation, that is perfectly clear. Then on the same page, line 40, "Also lampblack, plumbago, and carbon in various forms mixed with tar, and kneaded so that the same may be rolled out into wires of various lengths and diameters; each wire, however, is to be uniform in size throughout. If the carbon thread is liable to be distorted during carbonisation it is to be coiled between a helix of copper wires." Then he explains how the copper wire is to be eaten away after carbonisation. Then, on line 51, he says:—"With substances which are not greatly distorted in carbonising, they may be coated with a non-conducting, non-carbonising substance, which allows one coil or turn of the carbon to rest upon and be supported by the other." There are other passages in the specification which show clearly that what was contemplated always was making a filament, and in these cases rolling it before carbonisation, and one finds this, that Sir Frederick Bramwell, who was the leading witness on the part of the plaintiffs, does recognise the importance of making the filament before carbonising it, and relies on what he thinks exists there, the filament existing before it was carbonised. I will not read his evidence again in this case, but on p. 19, in answer to questions in the early part of his evidence, we find this:—"Do you find in the specification that the filament is to be formed before or after carbonisation? A. Before carbonisation." And then, I think, in the re-examination, he sums up in these terms, in answer to questions of counsel and judge as to what he thinks of great importance:—"Mr. Aston: In not one of the prior specifications was there any other method of dealing with carbon intended to be used in any incandescent lamp other than shaping the carbon previously made, and giving it the form it was intended to give it?"—that is to say, previously the burners, or whatever you like to call them, were carbon, and then you cut them into the form required by the person who was making the lamp. "Mr. Justice Butt: There is nothing beyond shaping the carbon previously made? A. Where carbon alone is used I believe that is so. Where sticks and pencils and things of that kind are used I think you will find they are made out of that which was carbon before they were manufactured. Mr. Aston: So that shaping was by means of a saw or file! A. A saw and file.—Q. Edison does not make his filament in that way? A. No, he does not.—Q. He makes it in various ways, forming the filament first, and then carbonising it afterwards? Mr. Justice Butt: That is really quite clear on the evidence in chief, that he makes it of any fibrous material, and then turns it into carbon instead of taking carbon and sawing and filing it down." So that there Sir Frederick Bramwell, in the beginning and in the end of his evidence—the judge then holding that that was the result of all the evidence—points out specifically that in his opinion that was essential as regards what was called the filament or thread here—that there should be a filament formed, and that that filament should be afterwards carbonised. That being so, if the other Lords Justices agreed with me in the construction to be put upon this specification, I think the proper course would be to ascertain by one of the ways offered on behalf of the defendants here—but so as not to divulge that which is their trade secret—how it is that the filaments, if they are to be so called, which are used by

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them, are in fact made. It was said by Mr. Aston—and in fact it was admitted in the course of the argument, and it was that which the whole argument and the evidence proceeded upon—that the filament of the defendant was made into that shape before it was carbonised, and there was a passage which no doubt very much supported that view, because at the end of Mr. Rawson's evidence there was a passage which was much relied on by Mr. Aston as showing that that was so. It is at the end of his cross-examination. "Never mind what Edison has used. Your answer is quite sufficient. A deposit of carbon which is caused to be deposited so as to secure your filament to the platinum wire is a deposit of carbon put there after the filament is formed? A. Yes."

Mr. ASTON: Yes; that is to form the terminals.

Lord Justice COTTON: Oh yes, I quite understand that. I was going to explain that. The carbon filaments are joined by the defendants in a particular way, not that of Edison, to the wire, and that is what Mr. Aston is speaking of. "Mr. Justice Butt: What is that answer? Mr. Aston: A deposit of carbon, which Mr. Rawson says he employs to effect the junction of his filament and platinum wires, is put there after his carbon filament is formed. A. And carbonised. Mr. Justice Butt: The carbon, he says, is placed there after the filament is formed and carbonised? The Witness: That is, by carbonising I mean what is usually commercially spoken of as carbonising. It is different in our case, but it is called carbonising." There he is referring to the state of the filament before the junction is effected between the platinum wires and the filament, and if that is not carefully looked to it might be considered that he was saying the filament was first formed and then carbonised. But, no; he says before the junction is effected the filament is a carbonised filament, and then only, and not after that has been performed, is the junction effected with the platinum wires. In my opinion, if, as relied upon by Sir Frederick Bramwell, and as relied upon by the Attorney-General, the forming of the filament before it is carbonised is the essence which runs through all the filaments mentioned in the specification, the question ought to have been put pointedly in cross-examination by the plaintiffs' counsel to Mr. Rawson. "I do not now ask about the time when you apply that which is to form the junction between the platinum wire and the filament, I do not ask about when that was done, but when do you carbonise the filament? Is it after the filament is made into a filament, or do you do it at the same time in some other way?" So that, I say, if the case rested on my opinion, I should desire to have that further evidence before I should say in this case that, although the patent is good, there has been infringement. But as the other Lords Justices agree in a different construction, which would, of course, have a different effect on the evidence, the appeal here must be dismissed.

Mr. ASTON: And dismissed with the usual consequences, my lord?

Lord Justice COTTON: Yes.

Mr. ASTON: There is an arrangement made between Sir Horace Davey and myself or the Attorney-General that under certain terms the defendants may continue the manufacture of their incandescent lamps.

Lord Justice COTTON: Do you mean continue generally, or pending the appeal?

Sir HORACE DAVEY: Pending the appeal, and it extended to both patents?

Mr. ASTON: It did, and I propose that that should continue until the decision on the second patent is given. May I respectfully ask when that may be expected, my lord?

Lord Justice COTTON: I hardly like to say. I expected we should have given it by this time, but I have not had an opportunity of consulting with the other judges.

Sir HORACE DAVEY: Your lordship will anticipate that the parties may desire—I do not say more than that—to go to the House of Lords upon this patent. In that case I shall probably be instructed to ask your lordships to suspend the injunction on certain terms.

Lord Justice COTTON: It now stands suspended until the other judgment is given.

Sir HORACE DAVEY: Yes, my lord, but the arrangement between my learned friends and myself extends to both patents. My learned friends think that the more convenient course is that that should be continued. That is, that the injunction be suspended until after the judgment is given in the Cheesborough case.

Mr. ASTON: On the same terms.

Lord Justice COTTON: We hope that will not be long delayed, but that is all we can say now.

Sir HORACE DAVEY: Your lordships probably will not object.

Lord Justice COTTON: Settle the terms between yourselves.

COMPANIES' MEETINGS.

Cuba Submarine Telegraph Company (Limited).

The thirty-first ordinary general meeting of the Cuba Submarine Telegraph Company (Limited) was held at the offices, No. 61, Old Broad-street, on Wednesday, the 2nd inst., under the presidency of Mr. Joaquin de Mancha.

The SECRETARY (Mr. James Scott) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, as you have taken the report as read, I hope you will have read it yourselves, and that you will agree with me that it is a very satisfactory one. I think it is one of the most satisfactory we have sent you for a long time. The business of the Company goes on gradually and prosperously, I am glad to say. Our messages increased last half year by 1,591, but I am sorry to say that the money result is not so favourable, the increase being only £1,459. As, however, I have before mentioned to you, people get clever in telegraphy. They have got codes by which they condense the number of words, and, therefore, we do not derive the full advantage we should otherwise get if they were more prolix. Still, I think that the results shown are most favourable, and everything goes on satisfactorily. The Santiago Harbour length has been repaired by Mr. Keith with his usual ability, and the report is that the whole of the cables are in good working order. I need not detain you much longer, I think, affairs being so prosperous; and I will now ask you to pass this resolution:—"That the report and accounts now submitted be received and adopted."

Mr. ALEXANDER F. LOW: I beg to second that.

The CHAIRMAN: If any gentleman has any questions to ask, I shall be very happy to answer them.

Mr. SQUIRE: May I ask whether the scheme called the "International" is still going on, or is it dead and buried? It was to include Cuba.

The CHAIRMAN: Do you refer to the one that the Government advertised about?

Mr. SQUIRE: No; the one advertised since we last met. I am told that it has been given up—from any probability of success, I suppose.

The CHAIRMAN: We heard of the new cable they were going to lay, and we understood that the capital was what is called "underwritten"—that is, taken up by a certain number of people, and that they would work it; but though they said that the shares were allotted, I understand, with you, that the thing is not likely to go. Even if it did, it would take some eight or ten years before it would affect us—that is, if they got the money. They propose a very large sum to carry out that project.

Mr. SQUIRE: They proposed £100,000, and to commence at the Azores.

The CHAIRMAN: £600,000, I think; but I do not believe the thing is likely to go from what we hear.

Mr. GREENWOOD: It is scarcely right that the whole of the congratulations should come from the Board. Shareholders have quite as much interest in the prosperity of the Company as the Board have, and I think we ought to recognise that the position has very much improved, and that we ought to be very much satisfied with the position of affairs. I do not for a moment attribute the whole of this prosperity to the good management of the Company; but I think some part of it is due to the Board and officers of the Company. I should not, on the other hand, for one moment suppose, in bad times, that the whole of the loss should be attributed to the Board and the officers; but in this case the executive are entitled to some meed of praise. I think the affairs of the Company are now in a more prosperous condition than I have ever known them to be, and we may congratulate ourselves on having earned an honest dividend. The prospects of the Company are also very much improved, and with improved traffic we may look for a larger income than we have received, as it appears to me that the whole, or nearly the whole, of the increased receipts go to profits, the expenses being scarcely enlarged by the increase of receipts—certainly not in any way in proportion. Looking forward, I would express the hope that the Directors will not go further than paying a dividend of 8 per cent. until we have accumulated a still larger sum to the credit of the reserve fund. I think that that fund should come to at least £80,000 or £100,000 before our dividend goes beyond 8 per cent. I know that when shareholders see that there is a larger profit, and wish to take all of it, it is very difficult to ask them to take less. I should, however, like to see the reserve fund increased to £80,000, which would be equal to £5 per share on all the ordinary shares of the company, and then it would be possible to reduce the share capital by returning £5 a share on the ordinary shares. Of course, it must be remembered that the preference shareholders have already received their full dividend of 10 per cent. per annum, and are not entitled to participate in the large accumulations, which would belong altogether to the ordinary shareholders. The time may come—and I think it is within reasonable distance—when the preference shareholders will have occasion to regret that they did not avail themselves of the opportunity that was mooted a little time ago to convert their shares into ordinary shares. However, they are still at liberty to do so. With our prospects, and the reserve fund, which I contend belongs to the ordinary shareholders, I think I should prefer, even now, the ordinary to the preference shares. As I commenced by saying, we may congratulate the Board and the executive on their excellent management of the affairs of the Company.

The CHAIRMAN: Our friend has spoken very well, and I quite agree with him. My mind has always been fixed on what he says—that our reserve fund should go on accumulating as much as possible. I should like to see it stand at £100,000. A cable is such a thing that at any moment we might find ourselves under the necessity of laying a new one. Though I do not agree with our friend Mr. Greenwood about returning money in case we ever get the reserve fund increased to £100,000, as I hope we may do, still that point must be considered when the time arrives. When we have £100,000 in hand we may call you together, and see whether it is wise to return a portion of the capital to the ordinary shareholders, and perhaps invite the preference shareholders to give way a little; but it is very difficult. A great many of these shares are held by trustees—ladies who reckon on the investment as a certain 10 per cent., and though you might lay before them the probability of getting 15 per cent. on ordinary shares, it would be very difficult then. Still, we shall bear the matter in mind, and when we get £100,000 at the credit of the reserve fund, we shall consider the question. In the past month we have had 3,956 messages against 3,485 in the same period of last year, being an increase of 471.

The motion was then put in the usual way, and carried unanimously.

The CHAIRMAN: The next resolution is, "That the following dividends be now declared for the half-year on the shares of the Company, viz., at the rate of 10 per cent. per annum, subject to income-tax, on the preference shares, and at the rate of 8 per cent. per annum, free of income-tax, on the ordinary shares, payable on and after to-morrow."

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Mr. Low : I second that.

The motion was put, and carried unanimously.

The CHAIRMAN : That is the whole of the business, and we are very much obliged to you for your attendance.

Mr. W. GRIFFITH : I must apologise for being late. Would you kindly answer one question ? Perhaps it has been answered already, however ? Have we anything to fear from this new company—the International Company ?

The CHAIRMAN : That question has been asked before, and I have replied to it. We do not think that the thing is likely to "go." They say that the shares have been allotted, but from the information we have we do not think that the project will go on at present, and that the capital is not likely to be subscribed.

Mr. GRIFFITH : It is sometimes a mere matter of form, but on this occasion I should not think it would be a matter of form to propose a vote of thanks to the Chairman and Directors for their able administration of our affairs. While other companies may be suffering, we are successful. We have to congratulate ourselves on a larger dividend, and undoubtedly in many respects we are indebted to the management for securing that dividend. I think, therefore, it is only proper that we should acknowledge our debt of gratitude, and return a unanimous vote of thanks to our Chairman and his able colleagues.

Mr. GODDARD : May I second that ! At the same time I must apologise for being late. You may remember that on the previous occasion I asked the Directors if they had taken into consideration any plan of getting rid of the 10 per cent. preference shares. I do not know whether any discussion has taken place on this subject, but I would still like to ask the same question—whether the Directors can see any way of putting by a reserve fund to a certain amount—say £5,000 or £10,000—so that the shareholders might give them instructions to meet any of the preference shares that come into the market—say, at 18. There are things of that kind occurring every day. Some one wishes to get rid of his shares, and the Directors might have an opportunity of buying some of them at a price which it would be desirable to get them at. I will not take up the time of the meeting, and I have great pleasure in seconding the vote of thanks.

The CHAIRMAN : Our solicitor, I think, would tell us that we are not able to buy these shares—that, according to the Articles of Association, we cannot invest money in our shares. The question of the redemption of these 10 per cent preference shares has been spoken of by Mr. Greenwood, and we are going to wait until we get an accumulation of £100,000, when we will take into consideration what is to be done. When we get the reserve fund at that amount then we shall see whether we can do something for the ordinary shareholders in the way Mr. Greenwood has suggested—that is, by returning a portion of the capital on the ordinary shares, so that they might derive on the reduced capital a larger interest. That was your idea, I presume?

Mr. GREENWOOD : That is so.

The CHAIRMAN : At present we think that our duty to you and to ourselves—and we are both equally interested in the welfare of the Company —is that the reserve fund should be accumulated for the present. At any moment we might be called on to make a heavy outlay, and therefore the stronger we are in the reserve fund the better for the Company. I am much obliged to Mr. Greenwood and the other gentleman for proposing a vote of thanks to us for having successfully carried on the affairs of the Company. For myself I do not take any praise. I think we have been very fortunate in getting very able coadjutors abroad and at home. Mr. Scott, as you all know, is always here ready to give every explanation, and there is hardly a day passes that I have not the pleasure of seeing him about some point or other. We do our best for you.

Mr. GRIFFITH : There is no doubt that the opinion of our solicitor is perfectly correct. We have not the power of buying our shares, but at the same time we can alter our Articles of Association and gain that power for ourselves. It is not one of those essential parts of the constitution which are fixed by the Memorandum, but one of those things that we can alter.

The SOLICITOR (Mr. Curtis-Hayward) : Not in the way you put it. You cannot take power to go into the market and buy shares. I do not mean to say that by a very roundabout means it has not been done and cannot be done ; but you cannot do it as you suggest, by getting powers enabling you to go into the market and buy shares.

Mr. GRIFFITH : There I differ from you. We cannot alter our Memorandum, but we can alter our Articles of Association.

Mr. GODDARD : Could we not put aside, say, £5,000, and then instruct the Directors to buy up these shares with that amount at a price which would be beneficial to the Company ?

The SOLICITOR : There is no power to reduce the capital in that way—by buying up shares. It has been distinctly held that you cannot, either by your Articles of Association as they stand or by altering them in any way, reduce your capital by buying up shares in the market. You can make certain arrangements with the holders for surrendering their shares. That is a matter of arrangement. It is a somewhat difficult process, though I do not say it cannot be done ; but as to the process which Mr. Griffith has mentioned, I think if he will go into the matter he will see that it is as I say.

Mr. COCHRAN : This discussion is somewhat irrelevant, but as it has been sprung on the meeting I should like to ask if our solicitor can inform the meeting whether it is competent for this Company, or any other company in a similar position, to put aside any portion of the reserve fund, and apply it to paying off any portion of the capital. I think we have evidence at hand that, should times change and the Company be unable to carry on, all classes of shareholders would have to bear a proportion of the misfortune. I should like to know whether in those circumstances our solicitor thinks it would be competent for the directors to apply any portion of the reserve fund to paying back a portion of the ordinary share capital without taking the preference shareholders into account.

The SOLICITOR : I think we had better not go into the matter. Let the point rise first.

Mr. GREENWOOD : I think the question of the conversion of the shares has been so well threshed out by the Directors, at my own suggestion once or twice, that I think it would be futile to go into that again, because they came to the conclusion unanimously that the circumstances were then not such as would warrant the bringing about of the conversion of the whole or half ; but the times are changed now, and all the preference shareholders have the right of converting their preference shares into ordinary ; and if there be any privilege attached to the ordinary shares, such as I have described, the preference shareholders have the right, if they think proper, to convert their shares into ordinary shares, and take their proportion of the benefit, in the same way as the ordinary shareholders. As to the question raised by the shareholder on my right (Mr. Cochran), it seems that it would be manifestly unfair to the preference shareholders to ask them to take back half their capital, as they would only get 10 per cent. on the remainder of their capital. To us £5 a share would be returned, and instead of getting 8 per cent. we should have a dividend of 16 per cent. on the other £5. To ask the preference shareholder, entitled to 10 per cent., to take back half his capital, without any increase of dividend, would be unfair.

Mr. GRIFFITH : It may be interesting to remark that only a month or two ago the very same question was raised about the reduction of capital in the case of the Direct Spanish Telegraph Company ; and one Court took one view, and the Court of Appeal took another view.

Mr. GREENWOOD : I wish them to convert their shares, but I am quite ready to wait. We have taken this half year, to be put to the reserve fund, an amount which, if all things go well, will be increased to a sum of £5,000 to be added to the reserve fund for the year. It is not much trouble—any schoolboy could do it—to reckon how long that rate of addition will take to increase the reserve fund from £66,000 to £100,000 ; and I think the preference shareholders will be very glad to convert their shares.

The CHAIRMAN : No one would convert his shares without a good premium. We shall take the matter into consideration, and I hope that we shall please both the ordinary and preference shareholders.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	Closing Prices. Feb. 2.	Business Done Week Ending Feb. 2. Highest.	Lowest.
Anglo-American	31, 32	32½	31
Do. Preferred	51, 52	53¾	51⅛
Do. Deferred	10½, 11½	11¼	10
Brazilian Submarine	10⅝, 10⅞	11	—
Cuba	11¼, 11¾	—	—
Do. Preference	18, 19	18⅛	—
Direct Spanish	1⅞, 2¼	—	—
Do. Preference	7, 8	—	—
Direct United States Cable	7⅞, 8⅛	8	7 15-16
Eastern Telegraph	10¼, 10½	10⅛	10⅛
Do. 6 per Cent. Preference	13, 14	13⅜	13⅛
Do. 5 per Cent. Debentures, 1899	105, 108	—	—
Eastern Extension	10½, 10¾	10¾	10¼
German Union	8¾, 9¼	8⅞	—
Globe Telegraph and Trust	4⅝, 4⅞	4⅞	4⅝ xd.
Do. Preference	11⅝, 11⅞	12	11⅝ xd.
Great Northern	13⅛, 13⅝	13⅛	13⅛
Indo-European	34, 35	—	—
Reuter's	6¾, 7¼	—	—
Submarine	190, 200	—	—
West India and Panama	¾, 1	¾	—
Do. 1st Preference	8½, 9	8⅞	8⅝
Western Brazilian	7½, 7¾	7¾	7⅛
Western Union 7 per Cent. 1st Mortgage	123, 127	—	—
Do. 6 per Cent. Sterling Bonds	101, 103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16, 15-16	—	—
Oriental	3-16, 5-16	¼	—
United Telephone	12¼, 12¾	12⅞	12⅛

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2, 2½	2⅜	—
Do. (fully paid)	3¾, 4¼	—	—
Swan	1¾, 2	1 15-16	1 9-16
Maxim Weston	3-16, 5-16	—	—

MISCELLANEOUS.

Telegraph Construction	39, 40	39¾	39
India Rubber, Gutta Percha, and Telegraph Works	23½, 24½	24⅜	23⅞

TRAFFIC RECEIPTS FOR JANUARY, 1887.

COMPANIES.	Jan., 1887.	Jan., 1886.	Increase.	Decrease.
Direct Spanish Telegraph	1,888	1,700	188	—
Eastern Extension	39,331	39,099	—	368
Eastern Telegraph	53,435	57,317	—	3,882

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NOTES.

THE SUEZ CANAL.—The whole length of the Suez Canal will very shortly be open for night navigation by all vessels provided with electric lighting apparatus.

"L'AIMÉ ELECTRIQUE."—M.M. Baudry and Co., of Paris, send us a copy of "L'Aimé Electrique," by M. Ph. Delahaye, which is now in its third year of publication.

TELEGRAPHIC COMMUNICATION WITH MOROCCO.—We are informed that telegraphic communication has been opened with Tangiers (Morocco), the rate being 7d. per word.

EDINBURGH UNIVERSITY.—Prof. G. F. Armstrong, who occupies the Chair of Engineering at the Edinburgh University, has arranged to include the subject of Electrical Engineering as a part of the curriculum of the college.

THE TELEPHONE WIRES IN FRANCE.—A measure has been introduced into the French Chamber of Deputies designed to give the Government a complete control over the erection of wires by telephone companies in France.

THE PRICE OF PLATINUM.—The price of platinum in Russia has of late fallen very considerably. In the month of October it was worth 4,700 roubles per pood, it is now sold at 3,000 roubles per pood. The pood is a little over 36lbs. avoirdupois.

THE ELECTRIC MOTOR AND ITS APPLICATIONS.—We have received from Mr. W. J. Johnston, of New York, a copy of "The Electric Motor and Its Applications," by Mr. T. C. Martin and Dr. Joseph Wetzler, editors of the *Electrical World* of New York.

ELECTRIC LETTER BOXES.—In America, in order to save the postman the trouble of knocking at the door when he places a letter in the box, an arrangement is being introduced whereby the raising of the flap of the box closes an electric circuit, and rings a bell.

ELECTRIC LIGHTING IN GERMANY.—The demands for connection with the Central Station now being erected at Lubeck by Messrs. Schuckert and Co. already exceed 2,000 lamps. The municipality of Breslau has appointed a committee to report upon a scheme for a central station lighting.

TELEGRAPH LEARNERS.—An open competitive examination for 30 situations as female telegraph learners in the General Post Office will be held on the 4th March, 1877. Applications must be made to the secretary, Civil Service Commission, Cannon-row, Westminster, not later than the 18th inst. The limit of age is from 15 to 18.

ENGLISH ELECTRIC LIGHTING COMPANIES UPON THE CONTINENT.—The French papers state that an English company has bought the Hotel Zuigg at Hamburg, in order to establish a central station for electric lighting. Another English company is said to be about to light the town of Elmshorn, in Holstein, by means of hydraulic power.

ELECTRIC METALLURGY.—We understand that at Par, Cornwall, a process, described as the "extraction of iron from China stone by means of electricity," has been for some time under experiment by the St. Austel Mining Company, and plant is now being laid down for the permanent application of the process upon a commercial scale.

SALE AT THE COLONIAL AND INDIAN EXHIBITION.—Messrs. Wheatley Kirk, Price and Goulty write us as follows:— "Referring to your paragraph in last week's issue, in which the average price realised by the cable is put at £50 per ton, we find on taking the total weights and values that the average price was £83 per ton, and in this calculation the weight of the insulation is included."

TUNGSTIC ACID FOR PRIMARY BATTERIES.—Dr. Eisenmann, of Berlin, has found that an acid solution capable (when used in a zinc battery) of being regenerated by mere exposure to the air may be obtained by forming a solution of 30gr. of tungstate of soda and 5gr. of phosphate of soda, dissolved in 350gr. of water, with the addition of a small quantity of sulphuric acid. The phosphate is added merely to increase the solubility of the tungstate.

DYNAMO TELEPHONES.—Mr. J. P. McLaughlin claims to have anticipated Prof. Silvanus Thompson in the construction of the so-called dynamo telephone. In the McLaughlin instrument, a single electro-magnet serves at one and the same time the purposes of call-bell, transmitter, receiver, and battery. We, however, fail to follow the inventor's meaning when we read that "an alternating current of opposite polarity" is used, and that in this way the theory of undulatory currents is exploded.

LOW-RESISTANCE INCANDESCENT LAMPS.—The Thomson-Houston Company are bringing out a low-resistance incandescent lamp intended for use in series with their arc lamps. The lamps are made for two different currents, one taking 6·8 amperes, and the other 10 amperes. The candle-power of the first type ranges from 32 to 125, and the volts from 14 to 56. The second type gives either 65 candles with 20 volts, or 125 candles with 40 volts. Each lamp is provided with an automatic circuit-closing cut-out.

THE TELEGRAPH WIRES OF THE WORLD.—*La Lumière Electrique* is responsible for the statement that the total length of the overhead wires at present in use in the whole world amounts to about 900,000 kilometres, with 1,540,000 kilometres of wire. This length of wire would go 38 times round the world, and would be sufficient to establish metallic circuit telephonic communication with the moon upon two independent lines. The number of posts required (on the terrestrial, not on the lunar lines) is about 14 millions.

NATIONAL TELEPHONE COMPANY.—This company opened an exchange at Dunfermline on January 31st. The subscribers' lines—at present fourteen in number—do not extend much beyond the town boundaries, but the trunk wire towards Stirling, Edinburgh, and Glasgow, is being vigorously pushed on, under the direction of Mr. James Townsend, the company's local manager for the district. Owing to its proximity to the Forth Bridge, Dunfermline is, without doubt, destined hereafter to become one of the chief telephonic centres in Scotland.

A CONSTANT CELL WITH THREE LIQUIDS.—Dr. Lugo, of New York, has devised a form of battery which is described as giving a current of great constancy. The result is obtained by the device of employing three distinct liquids. The zinc is placed in the outer cell in an alkaline solution; next comes a porous cell containing chloride of copper, and in this stands a hollow cylinder of carbon containing hydrochloric acid. The acid dissolves the copper which is liberated at the surface of the carbon, and maintains the strength of the chloride of copper solution perfectly constant.

TELEPHONES IN GERMANY.—The administration of the Grand Duchy of Hesse has decided to supply every village in the country with telephonic communication.—Several iron factors who live near the Austro-German frontier have their residences in one country and their works in the other. They have long wished to be permitted to run telephone wires across the frontier; but this was contrary to the international agreements. At length, however, an arrangement has been arrived at whereby telephone lines are allowed to cross the frontier,

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on condition that they also pass through some post office in each country.

TELEGRAPHIC COMMUNICATION BETWEEN ENGLAND AND FRANCE.—In the House of Commons on Monday last Mr. Montagu asked the Postmaster-General how long the monopoly of the Submarine Telegraph Company would continue; and whether he had considered how far it was desirable that telegraphic messages between England and France should be conveyed through the medium of a private company.—Mr. Raikes replied that the concession held by the Submarine Telegraph Company from the French and Belgian Governments would cease in January, 1889. The subject referred to in the latter part of the question was engaging his very serious consideration.

VARIATIONS OF THE TERRESTRIAL MAGNETIC FIELD IN BUILDINGS.—M. A. Witz has recently made some observations upon the values of horizontal component of the earth's magnetic field within the walls of a newly-built laboratory in the neighbourhood of Lille. In the construction of this building a good deal of iron had been employed, and the results showed a variation of *over 40 per cent.* in the values of H in different rooms. Although this is probably an exceptional case, yet the fact is alone sufficient to show the extreme want of reliability in the indications of any instrument for which the deflection depends on the value of H, except upon the spot where the calibration has been effected.

UNDERGROUND TELEGRAPH WIRES.—The Postmaster-General has sent the following reply to a question addressed to him with regard to the extension of underground telegraph communication between large towns:—"Sir: In reply to that portion of your letter of the 28th ult. in which you ask whether certain recent statements to the effect that arrangements are being made to lay underground wires on a large scale are correct, I am directed by the Postmaster-General to inform you that the question of connecting some of the chief towns in the United Kingdom by underground lines of telegraphs is now being considered by this Department, but that no decision has yet been arrived at."

HALIFAX.—The Halifax Town Council have decided to grant "reasonable facilities" to any electric light company willing to put down plant for lighting any portion of the borough with electric light. The decision of the Corporation was based on the recommendation of a committee which was appointed to consider whether it is desirable that the electric light shall be introduced into Halifax under corporate control. They have visited several places in the neighbourhood, and have had various offers from electric light companies. The intention of the resolution is to give the committee "power to treat" with the applicants; but the Corporation is not to be committed to any company or any scheme without its sanction.

WOODHOUSE AND RAWSON ELECTRICAL SUPPLY COMPANY. We have received from this company their complete price list, which is published at one shilling. The greater portion of the book is devoted to their special electrical supplies, which are now well known, such as incandescent lamps, switches, cutouts, electrical instruments, the Jensen electric bells, &c. The Upward chlorine battery does not, however, appear in these pages; we understand that a new type of this battery, embodying considerable modifications, will shortly be introduced. Besides their own specialities, particulars are given of most of the other leading articles used in the electrical trades, and their price list of electrical-engineers' sundries is likely to be found extremely useful.

H.M.S. "SEVERN."—The official trial of the electric installation on board H.M.S. "Severn" was brought to a satisfactory conclusion on Friday evening, the 28th ult., at H.M. Dockyard, Chatham. The lamps, 171 in number, are Edison-Swan 16 candle-power. There are also two powerful search light projectors by Latimer Clark, Muirhead and Co. The current is supplied by two A type Goolden-Trotter dynamos, driven direct by Willans engines, a double cylinder central valve engine driving the larger or 200-ampere machine, and a triple tandem engine driving the smaller or 100-ampere dynamo, both at 400 revolutions, the pressure at the terminals being 80 volts. The work of fitting the installation, including drilling through iron and fitting water-tight glands, was carried out by the staff of Messrs. Goolden and Trotter, of Westminster.

THE DISTRIBUTION OF ELECTRICITY IN SWITZERLAND.—In September last we referred to the formation of a company which proposed to lay down an electric railway and to furnish electric light in the districts of Vevey, Montreux, and Chillon. The power is to be derived from turbines supplied with water from the River Montreux, under a head of over 800ft. Considerable progress has already been made with the work. A reservoir having a capacity of 6,000 cubic metres has been built, and the canal by which the water is led from the river has been almost completed. The company is building its own dynamos, and one of 100 horse-power has been completed and gave considerable satisfaction on trial. For the electric lighting it is proposed to lay the cables underground in cement conduits. The railway will be worked upon the Siemens system, with overhead conductors. The line will be about eight miles in length.

THE ASSOCIATED CHAMBERS OF COMMERCE.—At the annual session of the Associated Chambers of Commerce, which was opened at Westminster on Tuesday last, the report of the executive stated, amongst other things, that the Chambers were pressing on important changes with regard to telegraphy. The destruction of telegraph wires by the late snowstorms was brought before the Chambers by the South of Scotland delegate, and a resolution was adopted to urge the Government to have the principal lines of wires conveyed underground instead of overhead. In regard to telephonic communication, resolutions had been placed on the paper by the Hull and Cork delegates with respect to the excessive charges made by the Post Office authorities for telephonic intercommunication, and a resolution was carried that a deputation should wait upon the Postmaster-General to urge the necessity of a material reduction in the rental charges of telephonic instruments.

THE TELEPHONE LITIGATION IN THE UNITED STATES.—The hearing of the argument in the telephone suit to test the Bell patent was commenced last week in the United States Supreme Court. The New York *Electrical Review* says:—"All the eminent counsel for and against the Bell interests are present. It is the expectation of the parties in interest, as well as the desire of the Court, that the contest over the substantial principles of the telephone shall be settled in this suit. There has not been for years such a formidable preparation for a hearing, nor has there been a suit in which such vast interests were involved. The printing of the record in the appeal in one of the cases alone cost $1,000. The briefs and the various documents relating to the suit in all its various phases would fill a good sized library. The briefs of the Bell Company are bound, at their own expense, in handsome Turkey morocco. The Court has granted forty hours, or ten days, for the hearing. Messrs. Bell and Gray are both present."

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An Automatic Target Indicator.—A French inventor has brought out a target which automatically registers, or rather indicates, the point struck by the bullet in a very ingenious manner. This is effected by dividing the surface of the target into numerous small squares, which are attached at the back to stiff springs. Behind each such square a metallic ball rests loosely at the bottom of an inclined plane. When a square is struck by a bullet the ball receives a smart blow and rolls up the incline; in so doing it closes a number of contacts, which number varies according to the position of the square upon the surface of the target. It will then be easily understood how an index, having a step-by-step movement, actuated by an electro-magnet, and placed at the firing point, is caused to indicate the result of the shot. A somewhat similar arrangement, made by Messrs. Eidsforth and Mudford, of Holloway, was tried some years ago at Wimbledon, and gave very good results, but for some reason or other its use was not continued.

Regenerating (?) Leclanché Cells.—M. Eugene Alliot, of Chateaurenault, employs a battery of eight Leclanché elements, with which he occasionally lights up a couple of small glow lamps for a few minutes at a time. Owing to the rapid polarisation of the battery it is, of course, impossible to get a full light for more than a few minutes. It, however, occurred to M. Alliot to try "to regenerate the zinc and the di-oxide of manganese" by means of a reversed current. By sending the current from a small dynamo through the cells once a week, for only a few minutes at a time, it was found that the Leclanchés did not tend to polarise when feeding the lamps nearly as quickly as before. It will, however, scarcely be admitted that the zinc has been "regenerated" by this process, although, no doubt, the depolarising effect of the reverse current results in restoring the cells to the most favourable condition for working, and where a current of sufficient E.M.F. is already available the hint may sometimes be worth taking.

The Electric Pyrometer.—At the Sèvres porcelain works the temperature of the kilns is usually ascertained by the aid of Siemens's electric pyrometer. Most of our readers will be aware that this apparatus consists of a coil of platinum wire, which is placed in the furnace, the temperature of which is then ascertained by measuring the resistance of the coil, and comparing the result with a table of temperature. Unfortunately, M. Lanth, managing director of the works at Sèvres, and M. Vogt, the chief of the chemical department, have ascertained that the indications of temperature obtained by this method are by no means of a reliable character. Two pyrometers which at first agree are found after a few weeks' service to give very divergent results. This is evidently due to a variation in the electrical resistance of platinum following some molecular change consequent on the high temperature to which the metal is exposed. The subject being one of considerable interest to the porcelain industry, the hope is expressed that someone will shortly succeed in discovering an alloy capable of giving in this direction better results.

Underground Telegraphs in France.—The laying of underground wires was commenced in France in 1880, but its development has been stopped on account of the great expense. Paris, Lyons, Marseilles, Bordeaux, Havre, Lille, Nancy, and some military centres are, however, now connected with cable. The cables already laid represent a weight of nearly 13,000,000 kilogrammes, and over 383,000 kilogrammes of asphalte have been used in laying them. The cost has been 37,572,000fr, and the system has given general satisfaction. The cables are laid about three or four feet below the surface. The system in France was adopted not so much to ensure constant communication between commercial centres as on military grounds. The Minister of Posts, when applying to Parliament for 53,000,000fr.—the original amount asked—spoke of the work as one of national defence. There was the danger that a tempest might just interrupt the mobilization of the army. Overhead wires are also easier to cut than the subterranean, though the cutting of the latter is not at all impossible, for the Germans no doubt know where the wires are laid in France as well as the French themselves.

The Incandescent Lamp Litigation.—On this subject Mr. Alexander Bernstein writes us as follows:—"Numerous inquiries have reached me of late from various persons, who ask whether the last decision in the matter of the Edison patent affects my new lamps of low resistance, and I therefore beg permission to reply through the medium of your esteemed paper. The decision makes it clear that of the four claims of the Edison patents only the second one is of importance. This claim protects the combination of a carbon *filament* with an exhausted glass receiver, through which the leading wires pass. It was conceded by the judges that the Swan lamp was a combination of a carbon with a receiver made entirely of glass, and leading wires passed through the glass; but it was agreed that the Swan lamp was a failure, because the carbon was too thick, and that by the introduction of the *filament* the Edison lamp became a success. The Swan carbon, which in the judgment is called a carbon rod, was $\frac{1}{32}$ of an inch in diameter; the carbons which I am using in my lamps have a diameter of $\frac{1}{22}$ of an inch. This at once settles the question. I may be allowed to repeat that in whatever manner the pending case respecting the Sawyer patent may be decided, the judgment will not affect me, as the carbons in my lamps are made without the use of any process for depositing carbon."

The Telegraph Disputes in Canada.—The Toronto journal, *The Week*, says:—"The private telegraph companies appear to have a case against the C. P. R., by which they, like everything else, are being absorbed. Private competition must, they say, be faced, but the C. P. R. has received immense subsidies from the Government, and attacks private enterprises virtually with public money. It would have been fairer and better had the company been confined to the national work which it has executed with so much energy and success. It is alleged that the private companies, being leased by the Western Union, are American, while the C. P. R. is Canadian, and that we ought to be glad as patriots to see American property destroyed by a Canadian rival. But the Montreal and Dominion Telegraphs, though connected with the Continental system, were built with Canadian money, and are owned, we believe, almost entirely in Canada. The Pacific Railway Syndicate was made up of houses or capitalists at Montreal, New York, London, Amsterdam, and Paris. No large proportion, we believe, of the stock of the railway is held in Canada; at least it is little heard of on our Stock Exchanges; and those magnates of the syndicate who individually hold large amounts are socially more Englishmen than Canadians. However, it is a question, not of patriotism, but of commercial justice. The C. P. R. will find that a policy of moderation is the wisest. If it is too grasping it will soon provoke a formidable coalition."

Elcrtric Motor Regulation.—Mr. Field, whose name is known in connection with a type of motor which has met with some success in the United States, has introduced a somewhat novel arrangement for automatically adjusting the brushes of a motor to the point of least sparking. Upon two opposite bars of the commutator, midway between the principal

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brushes, he places a pair of subsidiary brushes which are connected with a coil of high resistance, and through this with a small regulating motor. Both pairs of brushes are mounted upon the same rocking frame, amd this is geared with the armature shaft of the small motor. When the brushes are in their proper position, the second pair rest upon bars of equal potential, so that no current passes through this circuit. If any of the conditions of working are varied, so as to effect a displacement of the resultant field of the principal armature, sparking will commence (or, more probably, will *increase*) at the main brushes, and a current will at the same time be set up between the second pair of brushes, and will therefore traverse the coils of the regulating motor. The armature of the latter then revolves in such a direction as to restore the main brushes to the point of least sparking, carrying with it the small brushes to points of equal potential. This arrangement, though somewhat complicated and probably expensive, is said to give satisfactory results in practice. It is unfortunate that the point of least sparking is not, as a rule, also the point of maximum efficiency in running a motor.

TELEPHONIC COMMUNICATION.—Mr. Hugh Watt, M.P., writes as follows to *The Times* of Thursday:—"I shall feel greatly obliged if you will allow me to reply to the queries, suggestions, and complaints contained in a plethora of correspondence addressed to me with reference to my questions in the House of Commous regarding the telephone service, through the medium of your world-wide circulation, as I find it impossible to reply to these correspondents individually. I think no one who has studied, or is conversant with, the subject can do otherwise than agree with the consensus of opinion expressed by my correspondents, as to the desirability of the Government arranging with existing companies to take over the service throughout the country. The rapid adoption by the trading community of the medium of telephonic communication and its virtual indispensability renders the future development of this service a foregone conclusion. This being the case, the Government might now arrange with the companies upon more advantageous terms than some time in the future. The present condition of the service is as unsatisfactory as possible, and seems to me the only obstacle, excepting the scientific question of induction, which prevents the almost universal adoption of the telephone. I cannot presume to trespass on your valuable space to detail all the advantages which the acquisition of the telephone system by the Government would secure to the public, nor presume to prophesy the annual net profit which would very shortly accrue to the Government by the purchase of existing systems, say at something like the current prices of the stocks of the various companies. The success of these companies, as proved by the premium at which most, if not all, of their stocks already stand, although the service is in its infancy, renders it indisputable that, with a comprehensive system of underground cables, economy in the administration and general service, combined with greater promptitude and efficiency, the Government could supply the public at half the present rates charged and earn a very large surplus, much needed in these days of oppressive taxation."

ELECTRIC LIGHT AND FIRE INSURANCE. — The following remarks, which are well worth the attention of all electrical engineers, occur in the last number of the New York *Electrical World*:—"A recent fire in Philadelphia, which caused the destruction of a theatre that had been lighted by electricity, and during the progress of which two lives were lost, has been investigated as to its origin. During the examination experiments were made showing the inevitable results of bad construction and wiring; and the president of a well-known electric light company had the manliness to say that the specimen of wiring taken from the ruins would be easily capable of starting a fire. The coroner's jury evidently had no other course than to assign the outbreak of the fire to the bad wiring. The electric light is now too well established that an isolated instance, such as the one mentioned, can upset public confidence in its safety, but the incident proves that the danger from bad work, which we have more than once pointed out, still exists. The whole trouble, such as it is, lies in the undertaking of electric light installations by inexperienced and incompetent persons. No system of lighting, however good, electrical or otherwise, is safe in the hands of such, and it seems to us as if the time were ripe for the serious consideration of measures which will prevent the occurrence of fires from electric wires. We cannot expect that every one connected with the installation of a plant shall be an expert, but all ought certainly to have an amount of training which will give them an understanding of the work, so that they may be able to distinguish good from bad. It has already been suggested that this evil could be greatly diminished by an enactment compelling electric light *employés* engaged in responsible work to pass examination for competency, or, in other words, to be licensed. We have a precedent for this in the licensing of plumbers, and hence there would be no cause for complaint on this score. Or, as has been suggested, the electric light companies themselves might assume sovereign powers to control the competency of those entrusted with their work. The question of good workmanship and safe construction is one that concerns all companies alike, and with the rapid increase in electric lighting, steps ought to be taken which will prevent the flagrant disregard of common rules of safety. Electric lighting can be made, and is, the safest of all methods of illumination, and when it happens to fail there are the best of reasons for looking to hasty and incompetent work."

MAGNET COILS CONNECTED IN PARALLEL.—When the coils upon two similar but *independent* electro-magnets are changed from series to parallel connection it is known that the coefficient of self-induction is reduced to one-fourth of its former value. In connection with fast-speed telegraph work, the importance of this fact was recognised some time ago by the English Post Office, and this simple alteration resulted in a considerable increase of speed from the Wheatstone instruments. Upon telephone circuits the advantages are of course still more prominent. The facts of the case have recently been fully appreciated in America, although considerable difference of opinion exists among practical men in that country as to the physical cause of the phenomenon; "self-induction" is, we believe, as yet a name of occult and mysterious signification to the vast majority of American electricians. The following are the editorial remarks of the *Electrical World* upon this matter:—"While the 'practical' man is not so apt to search for the reasons by which improved results are obtained, it nevertheless is of prime importance to determine the laws upon which the change brought about is based. The winding of magneto bells may at first sight seem a subject of trivial or secondary importance, but when a well-known authority states that increased receipts can be traced to a change made in this respect, it seems proper to inquire further into the matter In our first number of the year it was shown by Mr. T. D. Lockwood how, by winding the magnets of a telephone call in parallel or multiple, the talking on the circuit was greatly improved. This article evidently, as is usual with Mr. Lockwood's writings, attracted considerable attention, and several correspondents

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have addressed us communications upon the subject. Two of these criticisms, while admitting the efficacy of the arrangement, are not in accord with the explanation heretofore given, and for which authorities have been cited by Mr. Lockwood. According to Mr. Farnham, an expert in telephony, the same improved result is obtained whether the magnet be 'multipled' to a certain resistance or actually wound to that resistance, and if no error has crept into his experiments, he is justified in the assertion. Should such be the case, the explanation given by him must be accepted, and the 'neutralising action' theory heretofore entertained will have to be modified. Mr. Farnham has made the study of this question a specialty for some time past, and has conducted a large number of experiments which strengthen him in the opinion formed on the subject. The question involved here evidently affects not merely the telephone service, but the telegraph and others as well, and hence its full discussion is eminently timely."

CHELMSFORD ELECTRIC LIGHTING WORKS.—We take the following paragraph from the *Essex Chronicle* of the 4th inst. :—The proceedings which took place on Saturday evening at the annual dinner connected with the Arc Electric Light Works and the Anchor Horticultural Engineering Works at Chelmsford were, as they have been on past occasions, of considerable public interest. The number of men present, which was about 170, shows unfortunately that those engaged in manufacturing machinery and gear for the production of the electric light have in common with many others suffered a a good deal from the prevailing depression, because the number does not greatly exceed one half the number that has attended on one or two past occasions. During the last year also the hands at the electric works, although reduced as we have indicated, have for a considerable period only been working short time. Mr. Crompton, however, who occupied the chair on Saturday evening, had a somewhat better statement to make in reference to the present and immediate future. Only two days previously the Arc Works had resumed full time, Mr. Crompton explaining that this improvement was caused by their having received an order to manufacture the largest dynamo machine in the world. This machine is to be as big again as any dynamo ever made at these works before, and four times as big as any made elsewhere in the country. The new machine, we believe, is to be used for smelting aluminium in America. Mr. Crompton pointed out, what is especially hopeful, that if the firm make a success of this dynamo they will be entrusted with the manufacture of many more like it. On the other hand, he mentioned that in consequence of the increased competition which had arisen within the last two years, the prices received by the firm for making a dynamo machine is less than one-half what it was a couple of years back. Everybody engaged in business will be able to sympathise with a firm which has been so suddenly called upon to meet a cutting trade of that kind, and they will sympathise with it all the more keenly when they learn that the price of the materials used remains the same, so that if a profit is to be made, it must be made simply by more economy and improved arrangements. According to Mr. Crompton, there is now in the manufacture of these machines so small a margin that if the slightest mistake be made the firm sustains a loss. Nevertheless, he is not without sanguine expectations for the future, and it is not an exaggerated compliment to say of Mr. Crompton that if anybody is to be counted upon for making the electric light a commercial success he is probably the man. Mr. Albright, another member of the firm, also held out a cheerful prospect of work in the manufacture of electrical motors and gear for launches at the Royal Albert Docks and also for electric tramways.

THE "ELECTRO-CALORIMETER," FOR THE MEASUREMENT OF ALTERNATING CURRENTS.—In Volume I. of De la Rive's "Treatise on Electricity," Chap. IV., page 33, occurs the following passage :—"This method consists in using the helix of Breguet's metallic thermometer, instead of a platinum wire, to appreciate, by the calorific effects, the energy of the dynamic electricity. Breguet's helix is composed of three superposed metallic plates, so narrow and so thin that the slightest change of temperature makes it twist and untwist by means of the unequal dilatility of the three metals, platinum, gold, and silver, of which it is formed. The helix is fixed by its upper extremity to a metal support, which is placed in communication with one of the poles of the pile. To its lower extremity, which is free, is soldered a small vertical platinum wire that is lightly plunged into a capsule filled with mercury, into which the other pole enters by means of a wire. This same free extremity carries a horizontal needle, which, by the number of degrees it traverses on a circular division, indicates the elevation of temperature that the helix has undergone." An instrument constructed upon this principle was employed by De la Rive in his researches upon the law of the heating effect of the electric current in different metals, and also upon the phenomena of thermo-electricity. The method of De la Rive was, however, adversely criticised both by Lenz (*Pogg. Ann.* Vov. XLVIII., p. 383), and by Poggendorff (*Wiedemann's Die Lahre von der Elektricität*, Vol. II., p. 389), who maintained that the indications of the instruments were not proportional to the total heat generated by the current in the spirals. This they asserted on the ground that the current would divide itself between the several metals in proportion to their specific resistances and connection, and hence an unequal heating would take place, resulting in transfer of heat across the riband. That such an effect is necessarily produced is undeniable ; but it remained to be ascertained whether or not any error of importance was thereby introduced. This investigation has now been undertaken by S. Roiti, who in a recent number of *Il Nuovo Cimento* has shown that the error due to this cause is in practice entirely negligible. Hence, S. Roiti has contructed an instrument upon this principle (embodying certain improvements), which he proposes to employ for the measurement of the work done by an alternating current in a circuit of known resistance. We fear, however, that there exists a further source of inaccuracy which applies to every method of measuring the work done in a circuit conveying an alternating current which depends upon an assumed knowledge of the resistance of the circuit. This arises from the fact that entirely apart from all questions of self or mutual induction, the actual resistance of a wire (the resistance which, when multiplied by the square of the current represents the rate of expenditure of energy) is not the same for an alternating as for a continuous current. The alternating current is not equally distributed throughout the cross section of the wire, but tends to fly out, as it were, to the periphery. Hence, for instance, one reason why the disc forms adopted in the Gaulard-Gibbs transformer has an advantage over wire of circular section. The importance of this effect depends in part upon the value of the periodic time ; it is, however, much less in the non-magnetic metals than in iron, and in practice may perhaps, as a rule, be negligible. S. Roiti's electro-calorimeter consists of two superposed Breguet spirals, one of which has the silver on the inside, and the other on the outside of the riband. A mirror is attached at the point of junction, and matters are so arranged that the movements of each of the spirals tend to deflect the mirror in the same direction. The whole is enclosed in a double brass envelope containing water, with a suitable window for observing the deflection of the mirror.

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SOME NOTES ON THE THEORY OF THE TELEPHONE, AND ON HYSTERESIS.

BY OLIVER HEAVISIDE.

As was found in the early days of the telephone, its cores need to be permanently magnetised before it becomes efficient. I refer, of course, to the ordinary magnetic telephone, in which an iron disc is attracted by an electromagnet, which does not differ essentially from a common Morse instrument with a flexible armature, with the important addition that the electromagnet is permanently polarised. The permanent magnetisation may be communicated by a permanent current in the circuit, or, in the usual way, by employing a permanent magnet on whose pole or poles the coils are placed. But the permanent magnetisation, except of the iron disc, is not essential. Thus we may abolish the magnet and core from the telephone, leaving only the coil and disc, and produce the necessary permanent field of force by means of an external magnet suitably placed. The efficiency is then greatly increased by inserting a soft iron core in the coil. Similarly, we may destroy the efficiency of a complete telephone by an external magnet, or we may increase it, by suitably placing the external magnet so as to, in the first case decrease, and in the second increase the strength of the permanent magnetic field. And if we carry the destruction of the magnetic-field by the external magnet so far as to reverse it, and bring it on again strongly enough, we restore the efficiency of the telephone. That is, the permanent polarity may be of either kind. The disc is strongly magnetically attracted in either case, and that is the really essential thing. Most of these facts, if not all, are pretty well known, but it appears to be different as regards their explanation.

A good many years ago I read in Mr. Prescott's work on the "Telephone," an article by Mr. Elisha Gray on the subject, containing some of the above facts, and, in particular, describing the effect of a permanent current in the circuit. He looked upon the necessity of a permanent field of force as a great mystery, and suggested some reasons for its necessity that appeared to me to be unwarranted and inadequate. I now observe that Prof. S. P. Thompson, in his recent paper, "Telephonic Investigations," remarks upon this question (*Electrician*, Feb. 4, 1887, pp. 290, 291). Whilst not explaining the necessity of a permanent field, he brings in to complicate the thing such matters as hysteresis and the curve of induction referred to magnetic force, which do not appear to be materially concerned. I have very little acquaintance with telephonic literature, and, therefore, it may happen that the following explanation has been already well threshed out, and accepted or proved to be erroneous, as the case may be; but the perusal of the remarks of so learned an authority as he whom I have mentioned has suggested to me that the following explanation may be not only generally useful, but even absolutely novel to many of my readers. Its very simplicity, however, combined with its ignoration by Prof. Thompson, causes me to be permeated by an uneasy feeling that I may have been, in my telephonic and other experiments of the last few years, blindly nursing a mere clothes-bag, instead of the real article. I hasten to rid myself of it.

The stress between the iron disc and the poles of the electromagnet varies, under similar circumstances, as the square of the intensity of magnetic force in the space between them. There is no occasion to consider the relative intensity in different places, or to perform integrations, as we have merely to deal with the fundamental fact of the stress on the diaphragm varying as the square of the magnetic force. Now, as we cause this diaphragm to execute forced vibrations by varying the stress upon it, we should make the variations of stress as great as possible in order to obtain the greatest amplitude of vibration, and the greatest intensity of sound from it

Suppose, then, that there is a permanent field of intensity H, producing a steady stress proportional to H^2, and that we vary the stress by means of the magnetic force of undulatory currents in the coils. Let h be the amplitude of the undulations of magnetic force, small in comparison with H, so that we vary the real magnetic force from $H - h$ to $H + h$, through the range $2h$. This is quite independent of H, so that if it were a mere question of the intensity of magnetic force, we could just as well do without the permanent field, except for a reason to be mentioned later. But the stress varies from being proportional to $(H-h)^2$ to $(H+h)^2$; or the range is $4Hh$, not troubling about any constant multiplier. That is, the stress-variation is proportional to the *product* of the intensity of the permanent magnetic force into that of the undulatory magnetic force. This contains the explanation.

We see at once that it is in at least approximate agreement with facts. For, with the same weak undulatory current passing, which keeps h constant, we know that the intensity of sound continuously increases as we increase the intensity of the permanent field. And, keeping the permanent field the same, we know that the intensity of sound continuously increases as we increase the amplitude of the current undulations, and therefore h. The question of exact proportionality is an independent one. We have got already what appears to be the main explanation.

Now to consider some other points. It has been assumed for simplicity that H was several times h. In a telephone H is a very large multiple of h under ordinary circumstances. But as H is reduced, or h increased sufficiently, the effects change. Thus, if $H = h$, the magnetic force varies from 0 to $2h$, and the stress from 0 to $(2h)^2$. And if H is less than h, the magnetic force varies from a negative to a positive value, whilst the stress varies from a positive value through zero to another positive value. In the extreme, when the permanent field is altogether abolished, whilst the magnetic force varies from $-h$ to $+h$, the stress varies from h^2 through zero to h^2 again. The disc is therefore urged to execute vibrations of double the frequency of the current undulations. It is similar to sending reversals through a Morse instrument, when the armature will make a rap for every current, positive or negative, or two raps for every complete wave. This alone would be, I think a serious hindrance to getting good speech from a magnetic telephone without a permanent field. But, with ordinary speaking currents, the double vibrations, in the absence of the permanent field, are insensible. On the other hand, when we put on the strong permanent field they are non-existent, *i.e.*, in the stress variations, as there is no reversal of the magnetic field, but only a change in its intensity.

But we may easily examine the effect of h alone, or in combination with H of a similar strength, by means of a vibrating microphone sensitively set, producing a very large variation of current in the circuit of battery, microphone, and telephone. Here the current is equivalent to the co-existence of a permanent current and of an undulatory current, and the latter may be made not insignificant compared with the former, even $\frac{1}{4}$ or $\frac{1}{3}$ its strength. It is not a matter of indifference now which way the current goes. In one case the permanent current increases, and in the other it decreases the permanent magnetic field of the magnet, producing corresponding changes in the intensity of the sound. We may cancel the permanent field by an external strong magnet, approximately, or make H small compared with h. Then the disc is attracted both when the current is above and when it is below its mean strength.

We cannot increase the efficiency of a telephone indefinitely by multiplying the intensity of the permanent field. In the first place, the disc becomes stiffened under strong attraction, so that ultimately a large increase in the stress makes little difference in its displacement. Again, when the core is very strongly magnetised, we may expect that the effective inductivity of the core, so far as variations in the magnetic force are concerned, to be reduced, so that undulations of current of given amplitude will not continue to produce stress variations proportional to the amplitude of the current.

There are many other things concerned, of course, between the stress variation and the intensity of sound, especially mechanical; as, for instance, the multiplication in the intensity of certain tones, especially the fundamental of the disc, which has also the disagreeable result of keeping up a sound after it should have ceased.

The application of the preceding is not merely to the telephone, but to various electro-magnetic instruments. I frequently make use of the multiplying power of a permanent

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magnetic field. For example, to make a trembler bell go with a weak current; or to make an electro-magnetic intermitter go firmly with a current that, unassisted, would do nothing. Thus a strong permanent magnet takes the place of a strong permanent current. It should be so placed as to increase the strength of field due to the electro-magnet.

In the other way of getting power, by having a movable coil in a strong permanent field, first done, I believe, by Mr. Gott. in 1877 (*Journal* S.T.E., Vol. V., p. 500), the action is different, as it is the electromagnetic force on the moving coil that is operative. There is no stress on the coil when no current passes in it. But when a current passes the torque may be taken to be proportional to the intensity of the permanent field and to the current passing, as in the other case.

In conclusion, a few words, from my own point of view, of course, on the subject of the hysteresis which has lately come into fashion, and which has been perhaps rather overdone by some writers. It is, substantially, an old thing in a new dress. Iron exposed to magnetising force usually, perhaps always, more or less, becomes magnetised intrinsically as well as elastically, just as ductility is probably always in action to some extent in a strained elastic spring. Thus, in changing the elastic magnetisation, which does not involve any recognised or as yet recognisable dissipation of energy, we change the intrinsic magnetisation, which does. But that there is no sensible dissipation of energy in an iron core placed in a rapidly intermittent or undulatory magnetic field of moderate strength I assured myself of experimentally some years ago, as I mentioned in *The Electrician* for June 14, 1884. I repeated the experiments in a far more effective form last year (*Electrician*, May 23, 1886). The method is very simple and obvious, being merely to show that iron, when sufficiently divided, is exactly equivalent to self-induction. Use the differential telephone or the bridge. The former is a handy little thing, but the latter is much more adaptable and generally useful. Take two coils of the same resistance but of widely different inductances, and complete the balance by making up the deficit with iron. If sufficiently divided, the changed resistance due to dissipation in the iron vanishes or becomes exceedingly small. I formerly used a bundle of the finest iron wires I could get, and the residual effect was small.

In the repetition I used iron dust, worked up with wax into solid cores (1 wax to 5 or 6 iron by bulk), and the residual effect is far smaller, scarcely recognisable. But if the magnetising force be made stronger there is a small increased resistance, which can hardly be due to the Foucault or Farrago currents in the insulated dust. It is possibly due to hysteresis. But at the same time the variation in the inductivity is recognisable, so that the effect is complex. It is clear that in the case of telephone speaking currents, dissipation (except F) is nowhere, whether the core be permanently magnetised or not.

We require strong forces to make hysteresis important. Even then it is probable that when the variations of force are very rapid (undulatory, not with jerks) dissipation due to hysteresis may be considerably reduced, and the results of Ewing and Hopkinson not be applicable.

INCANDESCENT LAMP MANUFACTURE.—VII.

BY J. SWINBURNE.

Animal Carbon.

The most obvious material is horsehair. If horsehair or any similar substance is heated rapidly it melts and tumifies, so animal carbons must be heated very gradually and very slowly.

Such things as horsehair are not fit for commercial use, because they do not admit of making carbons wholesale with the same radiating surface.

Mr. W. Stanley took out patents some time ago for making carbons of carbonised hair, and found the pig-tails of Chinamen afforded the most even and uniform material. Mr. Stanley showed the writer a sheaf, or whatever it is called, of pigtail fibres which he had obtained, and they certainly were very straight and even. Mr. Stanley had also made some lamps of this material, and was working the subject out quite seriously.

Catgut can be carbonised if the heat is raised very gradually indeed. The writer has had catgut carbonised by being placed in a saggar in a pottery kiln. Even then it was not quite free from lumps. It was very hard, and had a bright, glossy surface.

Silkgut, which is what Mrs. Carlyle would call the "bits of internals" of the silkworm, pulled out straight, behaves in the same way.

Gelatine, again, which has much the same chemical composition, swells up, and is quite useless. The writer tried mixtures of gelatine and agar agar jelly in various proportions, but they were useless.

Silk thread has suggested itself to most people. Such silk as the "Tower twist" sometimes makes very good carbons, but there are several great objections. The first is that if the silk is heated very slowly each fibre remains separate, and the resulting carbon is weak, and if it is heated too quickly it runs or tumifies. It should be just heated quickly enough for the separate fibres to agglomerate into one without making the carbon uneven or lumpy. The next objection is that the resulting carbons are not all similar. They have, therefore, to be sorted out by hand into batches before use. Such trouble as this would condemn silk altogether if it were not that it makes such a very durable carbon. So far, twisted silk has been spoken of, but this is apt to make the carbons writhe in the lamps. Silk is plaited into beautifully even thread used in surgery, and for fishing lines. The writer has had various sizes of plaited silk, both round and flat, specially made for him.

Silk contracts enormously on being carbonised, and this gives rise to much trouble, as the thread is apt to be weak in the arch or top of the loop.

When a carbon shows a twist it can be generally said whether it has been made from silk or cotton, because cotton thread is twisted in a left-handed screw, while silks are most often right-handed.

There are many other kinds of silk. There is a sort of silk cord made called dentists' twist, which is made from China silk with very thick fibres. This is not made thin enough for lamps; but when specially made in small sizes it sometimes made very perfect carbons, and sometimes very bad ones. The success seems to depend entirely on the rate of raising the temperature, and therefore cannot be easily made certain.

The silk threads may generally be dipped with advantage in the fuchsine solution already mentioned. It is easy to arrange a continuous process by which the thread is pulled through a vessel of solution, and is then passed over a pulley on the ceiling. By this means when the thread, after descending, is wound on to a reel or drum, it is dry enough not to stick together. The drum is driven very slowly by a small belt from some convenient shaft.

Carbons made from plaited silk passed through a solution of fuchsine are the strongest of any the writer has tested, being considerably more durable than amyloid thread made by sulphuric acid. The troubles resulting from want of uniformity, on the other hand, are very great. Both the writer and Mr. Bernstein have used plaited silk for making carbons for low-resistance lamps. The material has some advantages for this purpose, but to manufacture low-resistance lamps in large quantities another requirement is necessary, that is uniformity of specific resistance. This will be more fully discussed under the head of low-resistance lamps.

Mr. Ram has lately been working out a method of squirting threads of silk. Mr. Ram's ingenious process depends on the solubility of silk in cuprammonia.

Cuprammonia also dissolves gelatine, and oddly enough the solution is red. The addition of a little silk or gelatine to the solution of cellulose in cuprammonia might be an advantage.

Chemically Deposited Carbon.

Mr. A. Smith has taken out a patent for a process of depositing carbon. According to his specification hydrochloric acid gas is passed through furfurol or fucusol. Furfurol is an oil with the same sort of chemical composition as cellulose, sugar, &c. Fucusol is isomeric with it. The hydrochloric acid turns the furfurol black, and this black liquid is poured on

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a glass plate. Another plate is then laid on the top, distance pieces keeping the two plates the desired distance apart. When the liquid has set, which is after about a day, one glass is removed, and the sheet of black carbonaceous substance is floated off by water, and is mounted on a cardboard or wood support. When partially dried the sheets are cut into narrow strips of uniform width by a suitable knife, and the strips are bent into loops, and finally carbonised in the usual way.

Hydrochloric acid gas no doubt acts on furfurol by abstracting the elements of water, and leaving either carbon, or some compound with a high percentage of carbon. Oil of vitriol acts similarly. Mr. Smith says he sometimes uses a mixture of furfurol and oil of vitriol. He does not say whether this is used hot or not.

A black compound, which is probably the same, can be produced by the action of sulphuric acid on sugar, and on some other bodies. Furfurol is expensive, but if the carbons are carefully used that is of little importance, if they are better than those made from cheaper substances.

There is still another method of making carbons. Very small rods may be squirted from the same compositions as those used in arc light carbon manufacture. In fact very small arc carbons may be used in incandescent lamps. These are used in the Gérard lamp, and the question of the use of such rods in this kingdom may be of considerable importance since the recent litigation.

1886.

In our previous articles on dynamos we have referred to many well-known makers, but it must be understood that we have done little more than give the principal types of machines constructed. Most of the builders of dynamos make many machines for special purposes, with slight modifications introduced into their construction from the ordinary type. Thus, Figs. 30 and 31 illustrate machines built by Messrs. Crompton and Co. for ship lighting. One of the machines, it will be seen, is designed to be run with rope gearing, and illustrates one of several supplied to Messrs. Homes and Vaudry, of Liverpool, for use on White Star liners. The engineer of the ss. "Britannic," one of the ships supplied, writes as late as January 2 last that "the machines are excellent in design and construction, and give no trouble whatever." Fig. 32 shows a dynamo built by Messrs. Elwell-Parker, and classified by the firm as the B type of machine. Various sizes of these machines are built, and can be had either series, shunt, or compound wound.

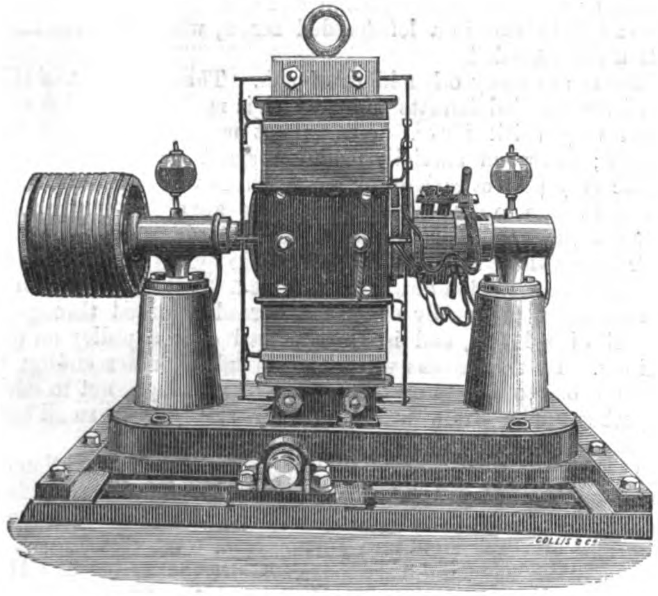

FIG. 30.—Crompton's Ship-Lighting Dynamo, White Star Line.

We have not yet mentioned the Gülcher Company's machines, for similar reasons given when referring to Messrs. Siemens. The type is in a state of transition and undergoing some modifications, so that it is preferred in these cases to wait till all the details are settled rather than to describe a dynamo subject to alterations. The company, as we have said, has carried out a large number of installations during the year, and seems to be entering upon an era of prosperity.

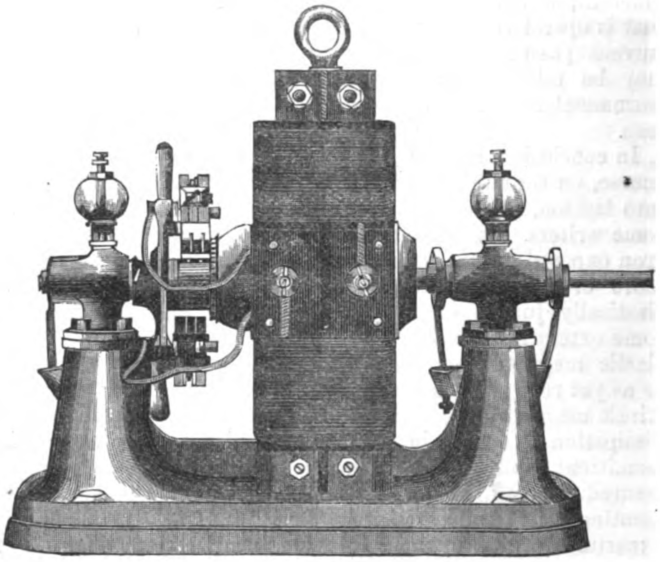

FIG. 31.—Crompton's Ship-Lighting Dynamo.

In October last we illustrated and described the machine built by Messrs. Chamberlain and Hookham, and it may be as well to repeat the illustration here (Fig. 33, next page), though for details we must refer our readers back to *The Electrician* for October 1st, 1886.

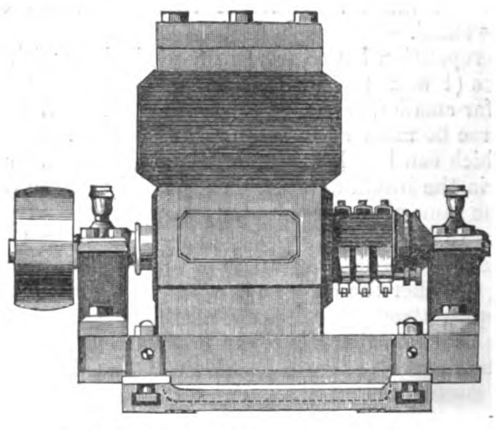

FIG. 32.—Elwell-Parker Dynamo (Class B).

Digressing from the immediate subject, "dynamos," to the almost necessary accessory of an installation, "storage batteries," we have to record that the Electrical Power Storage Company's business has, during the past year, progressed to a marked extent, probably more than that of any other electrical manufacturing firm in Great Britain. Its accumulators have been largely utilised for lighting purposes, a battery being placed in nearly every important installation in the kingdom. Several orders have been shipped for use abroad, and among these may be mentioned one of 100 tons of plates supplied to the Imperial Continental Gas Association in Vienna. The various Foreign and Colonial Governments have been large purchasers of cells for use principally in connection with ship lighting and torpedo work. The Merchant Service has also been supplied with several batteries, and these have proved to be the most useful and reliable adjuncts to ship installations, owing to their capability of relieving the machinery during

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repairs, and of supplying a few lights after hours or during the day. The very successful results obtained with this company's accumulators used for train lighting have induced the railway electrical contractors to place considerable orders with the company in view of largely extended business in this direction.

The electric motive power industry has also shown great development, the company having supplied cells for this purpose capable of giving several hundred horse-power. The successful Channel trip of the launch "Volta" will still be fresh in the minds of our readers, as also the recent trials with the submarine boat "Nautilus," where E.P.S. accumulators, manufactured by this company for Messrs. Elwell-Parker, capable of discharging at the rate of 56 horse-power for about four hours, are employed. Further cells have been used for launches manufactured by the company for various clients, and it has also supplied firms engaged in experiments on motive power, among whom may be mentioned the Electrical Traction Syndicate and the Electrical Locomotive Company.

The accumulator department of the company's works at Millwall has been working incessantly day and night throughout the year. Its instrument and motor shops have also been well engaged, having constructed several machines of equal efficiency to those of the best makers, and equivalent in every respect as regards workmanship and finish. It has also devoted special attention to the design of switches, switch-boards, and accessory apparatus, its staff being fully aware of the absolute necessity of employing the very best instruments when dealing with electrical energy.

Several lucrative contracts for installation work have been secured, and among those executed may be mentioned the installation at the Prudential Assurance Company's offices, where a plant capable of supplying upwards of 1,500 lamps is fixed, and in satisfactory working order; the complete lighting of the North British Insurance Company's offices, the Bank of Rio de Janeiro, the Union Bank of Australia, Colonel Stebb's residence at Scarborough, &c.

The installation department is fully employed on a number of new installations and extensions, and it is fully anticipated that the business of the present year will considerably surpass that of 1886.

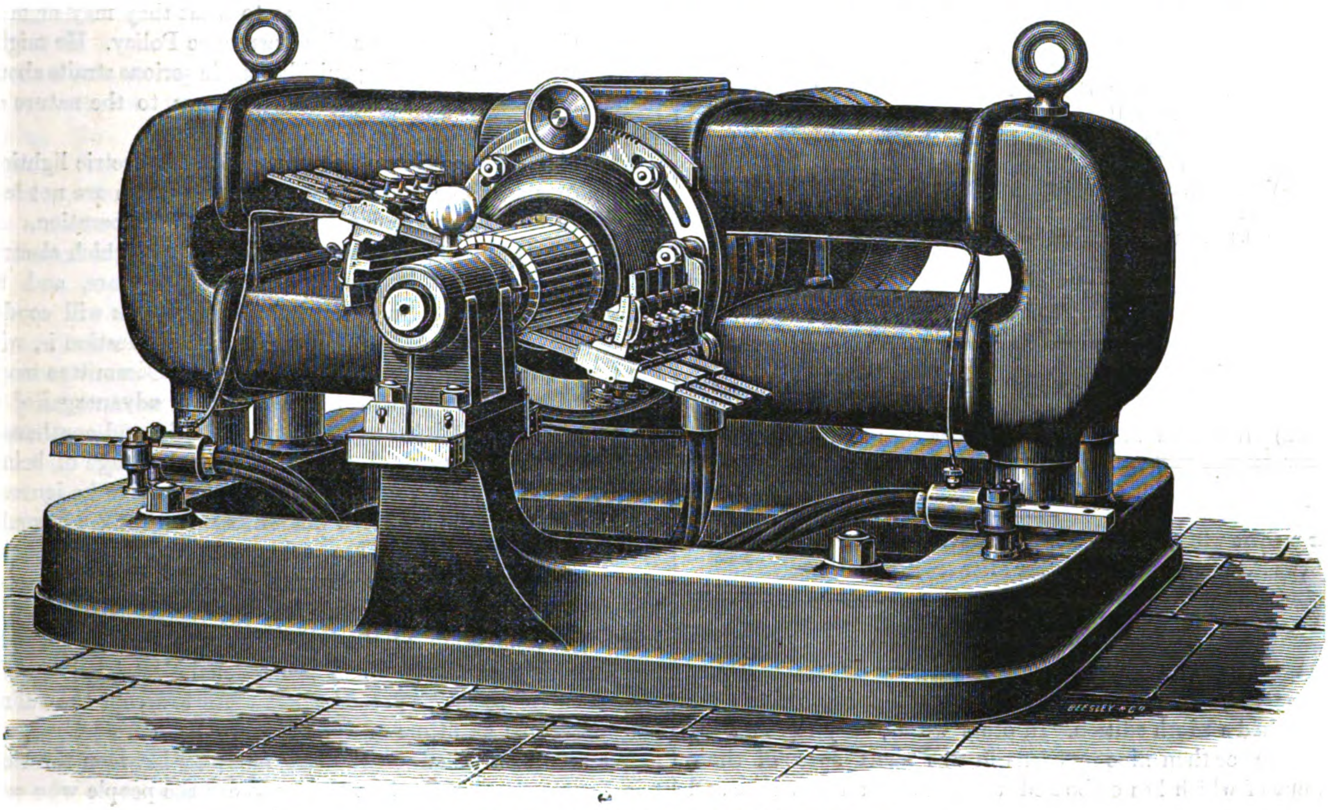

Fig. 33.—The Chamberlain and Hookham Dynamo.

THE ELECTRO-DEPOSITION OF ALUMINIUM.

In his "Electricity," &c., Mr. Sprague says: "The depositing of aluminium would be a process of great value in the arts," and then proceeds to state that several processes have been published, but none is of any practical value. Mr. Sprague also says that all the solutions he tried—acid, neutral, and alkaline—decomposed and gave off gas, but refused to deposit metal. He believes, however, that aluminium may be more readily deposited in alloy with other metals. Sainte-Claire Deville thought it impossible to obtain aluminium from aqueous liquids by electrolysis, though the experiment of Bunsen in the production of barium did much to shake his conviction. Like Mr. Sprague, Deville failed to obtain good results, although he tried all the processes known; and yet it is stated that aluminium can be deposited. Thus it is said that Corbelli, of Florence, deposits the metal by electrolysing a mixture of rock alum and the chloride of calcium or sodium, the anode being formed of iron wire covered with insulating material, and dipping into mercury placed at the bottom of the solution, and the cathode of zinc immersed in the solution. The aluminium is said to deposit upon the zinc. In 1854 and 1855 Thomas and Tilley took out patents for depositing aluminium from a solution of calcined alum in aqueous cyanide of potassium. The patents included the deposition of aluminium alloys. Amongst other statements made is one by Mr. J. B. Thompson, who asserted that he had been depositing aluminium on iron, steel, &c., at a temperature of 500° Fah.; but C. Winckler stated soon afterwards that plating with aluminium cannot be effected by electro-deposition. Jeancson's is an American process, a double salt of aluminium and potassium being employed at a specific gravity of 1·161, using three Bunsen cells, and a temperature of 140° Fah. M. Bertrand asserted that he had deposited aluminium on copper from a solution of the double chloride of aluminium and ammonium; and Gore's process is the simplest of all, for he is said to have obtained a deposit from a dilute solution of the chloride, by placing in it a porous pot containing dilute sulphuric acid and amalgamated zinc, the latter connected to a copper plate immersed in the chloride.—*English Mechanic.*

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 297
Some Notes on the Theory of the Telephone and on Hysteresis. By Oliver Heaviside 302
Incandescent Lamp Manufacture.—VII. By J. Swinburne 303
Retrospect of the Past Year. (Continued.) Illustrated ... 304
The Electro-Deposition of Aluminium ... 305
ELECTRICAL FIRE RISKS ... 306
Correspondence ... 307
Elementary Note on Graphic Methods. Illustrated ... 308
Contemporary Progress. (Continued.) Illustrated ... 309
Maxwell's Theory of Electricity. 311
The Electric Lighting Act (1882) Amendment Bill ... 313
Electric Motors in the United States ... 314
The Electric Light Industry in America in 1887 ... 314
Companies' Meetings—
Anglo-American Telegraph Company ... 315
India Rubber, Gutta Percha, and Telegraph Works Company ... 318
City Notes, &c. ... 318
Companies' Share List ... 318
Traffic Receipts ... 318

CITY NOTES.

Our readers will find these Notes separate from the more technical and News Notes, and placed together after reports of meetings.

ELECTRICAL FIRE RISKS.

The Rules drawn up by the Phœnix Fire Insurance Office some six years ago in respect to electric lighting risks have just reached a ninth edition. In other words, they have undergone no fewer than nine revisions in this short space of time, each one of which has embodied the lessons of experience and the discoveries of science brought down to date. It is fair to assume that this has generally been the case, for had it been otherwise the Rules would not have undergone so many revisions. It is true that the tendency has been in several directions towards greater stringency; but seeing that the electrical world itself has admitted that its earlier declarations on these points were mistaken, and seriously erred on the side of laxity, we cannot be surprised if the purely business instincts of the insurance companies betray a leaning towards restriction. But in some respects the Rules have been liberally modified; and on the whole nobody can say that they display a hard-and-fast adherence to their original form. On the contrary, the present edition, which is now before us, is evidence that the conditions of security laid down by the advisers of the insurance companies are constantly being shaped in conformity with every authenticated fact as it becomes known.

This being the case we are surprised to observe that in certain quarters the question is being reopened as to whether these famous Rules should undergo a revision avowedly in favour of the electrical engineer. We say avowedly, because, under a thin disguise of solicitude for the security of the insured, it is plain to be seen that he is being tempted to rebel against the conditions imposed by the insurer. One correspondent of a contemporary declares that the whole subject remains still in uncertainty, and professes to treat the Rules drawn up by the Society of Telegraph-Engineers in 1882 as being still in force. As a matter of fact, valuable as those Rules, or rather suggestions, may have been at the time, they were never adopted as a complete, much less as a final, pronouncement on the subject. It is well known that the Phœnix Rules have been framed with the assistance of some of the best practical and scientific experts available, the companies reserving to themselves the adaptation of advice so obtained to their business requirements, and especially to their own special knowledge of fire risks. The writer alluded to treats the subject as if there were several sets of Rules in operation, conflicting one with another, or at all events leaving electric lighting engineers and the people who employ them in grave perplexity as to what they may or may not do without jeopardy to a Fire Insurance Policy. He might as well argue that intending suicides are in serious straits about their Life Policy, because doctors disagree as to the nature of suicidal mania.

These imaginary grievances connected with electric lighting installations are to be remedied by measures which are not less imaginary in their conception and futile in their operation. A Committee is to be formed to ascertain the part which electric lighting has played in the fires of recent years, and to draw up Rules which electric lighting engineers will condescend to comply with. No doubt. But the question is, will the insurance offices be equally obliging? A Committee may, as the writer urges, possess the well-known advantages of a "Board;" but what is the use of escaping kicks and anathemas if you cannot command obedience? The advantage of being simply ignored is of very doubtful utility; and to be ignored is precisely the fate which a Committee of that kind would invite. The public, we are told with guileless candour, are often unaware of the dangers of an unprotected installation. Does the writer suppose that the Insurance Offices will leave the instruction of the public on this delicate point to remain solely in the hands of professional electricians? We should ourselves just as soon expect them to accept the ruling of professional gasfitters or dynamiters.

We are quite as anxious to see fair play between the electrical engineer and the Fire Offices as are the people who constantly complain of the Companies' Rules; and in respect to some of them we are ready to assert as loudly as anybody that they bear hardly upon installations. But before condemning them outright we should require to know what the Phœnix people have to say in their defence from the point of view of business men. It is this element of business which is so generally overlooked in these discussions. The offices, having to guard themselves against an acknowledged risk, make their regulations so as to reduce it to a minimum. They have no interest to serve in promoting electric light; on the contrary, their interest appears to lie in the other direction. It is stated that a number of fires have originated with electric lighting; and the fact is not at all calculated to encourage insurance, like ordinary fires, but rather to discourage electric lighting. This, indeed, is the lesson we have to take to heart, namely, that negligent, careless, or reckless installations—that is to say, installations carried out under no rule, except the rule of cheapness—bring discredit on the electric light, and tend to make the Insurance Office Rules more obstructive than they otherwise would be. Some of the

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offices apparently do not enforce the Phœnix Rules; for one of the biggest fires of last year is suspected on good grounds of being caused by bad work on the electric lighting plant of the premises; and yet the proprietors were heavily insured. The severest Rules imaginable would have been preferable to such a calamity.

On one other point the complainants seem to proceed under a misapprehension. If the question were one of assessment of risk the case would be wholly different; but the policy of the Companies is to discourage extra risks under extra premiums; and with regard to the electric light, no demand is made for extra premium, although when used in conjunction with gas, as is frequently done, the risk is undeniably greater. In this respect we think the Companies have acted handsomely. There was here a plausible pretext for obstructive tactics, which would have greatly hampered the progress of electric lighting had the guiding influence of the Phœnix been so inclined. Instead of this the risk is taken level all round, the one main condition being that lighting by electricity, like lighting by gas, shall be installed, not indeed in a particular way, but in one of the several ways deemed safe by the Companies' advisers. That their ideal of safety errs on the safe side is not to be wondered at, seeing that its object is to guard against the electric light adding anything to the danger already incurred under an ordinary fire insurance. In due time we may reasonably hope for a relaxation of these Rules, but at present the Companies can point to the fact that no fire caused by the electric light has ever yet occurred where the Rules have been in force, whereas several are known to have been caused by non-observance of these Rules. We agree with the remarks of our American contemporary, quoted elsewhere, upon a recent fire in Philadelphia: "Electric lighting can be made the safest of all methods of illumination, and when it happens to fail there are the best reasons for blaming hasty and incompetent work." And we are of opinion that the surest way to effect a relaxation of the Rules which are enforced in England will be to loyally work side by side with the Insurance Companies, who, after all is said and done, are masters of the situation.

CORRESPONDENCE.

STATIONARY ARMATURE CORES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you be kind enough to give me your opinion whether it is any benefit to have the soft iron inside the wire coils of an armature stationary? Is it worth any extra trouble to accomplish that?—Yours, &c., E. W. CRABTREE.

18, Sterling-street, Bradford, Feb. 5, 1887.

[This question is one which seems to exercise the mind of almost every electrical student at a certain stage of his career. We recently had submitted to us working drawings of a dynamo upon which a great deal of thought and skill had evidently been expended with a view to obtaining a stationary core under the best mechanical conditions. In this case, and probably also in that of our present correspondent, the objects which were expected to be attained were (1) the suppression of Foucault currents in the iron, and consequent possibility of using a solid core; (2) the avoidance of lead, and therefore the possibility of using fixed brushes. It is obvious that so far as the exciting field is concerned a stationary core will not tend to generate Foucault currents, and even in the case of the moving armature coils, if at each point in space the current remained constant throughout each revolution there would be little tendency to induce currents in the core. This point is rather an interesting one, for from another point of view, instead of considering the current as fixed in space, we may take it that the E.M.F. which would tend to be induced in one direction by the onward sweep of the coil would be counterbalanced by the induced E.M.F. in the opposite direction, resulting from the increase or decrease of current in the coils as they approach towards or recede from the brushes. However, the Foucault currents are not by any means entirely got rid of in this way, for supposing that we have only one turn of wire for each commutator bar, the space occupied by the insulation between the coils will still upset the constancy of the field with regard to its position in space. We may therefore conclude that, although Foucault currents would be perceptibly diminished, it would, in all probability, still be necessary to laminate the core. Secondly, with regard to the effect of a stationary core upon the lead of the brushes, the modern views which consider the function of the iron to be merely that of a conductor of the lines of force, and which attribute the distortion of the field solely to the cross-magnetisation of the core by the armature current, forbid us to anticipate that the angle of lead would be modified by such a change. This, at least, is our own view of the matter. It is, however, right to add that those who hold, with Professor Ayrton, that the lead is due to a "magnetic lag," would, we presume, expect to be able to suppress the lead in this way.—ED. *E.*]

INCANDESCENT LAMP PATENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There are special reasons why I can speak on this subject with exceptional authority and knowledge as regards what was done in the earlier stages, the period on which all important patent rights turn.

From the first commencement of Lane-Fox's work I was convinced of its importance. As engineer to the British Electric Light Company (Limited) I drew the first agreement he made in connection with his patents. Under my immediate notice thousands of pounds were spent on his work.

So, little excuse is needed from me in endeavouring to get his actual work and the points he developed well recognised. That they should be is of great importance to the immediate prosperity (in this not very go-ahead country in electrical matters) of electric lighting and distribution.

I feel strongly that the expenditure that the directors of the British Electric Light Company (Limited) went to, after sifting this matter—which I brought before them—bore important results, and the British Electric Light Company (Limited) pioneered important work in this, as they did in many branches of the heavy electric development of the last ten years.

The high resistance of incandescent lighting as it now exists was first described in one of Lane-Fox's patents, October, 1878. Let anyone interested read that patent, and they will then see in all its entirety and scientific accuracy the system of incandescent lighting now common. There is no disputing the fact that Lane-Fox was the pioneer and the exponent of the system of high-resistance light-giving media in a parallel circuit system of distribution with constant potential, which is, in fact, "the incandescent lighting of to-day." Edison, at a later date than this, deals with another method of working, *vide* his specification, later (in 1878) than Lane-Fox's above referred to, where he describes his tuning fork dynamo and elaborate arrangement for adjusting current to lamp, showing the total divergence of his ideas to Lane-Fox's.

The system described by Lane-Fox is the system now in use—the practical incandescent system of lighting.

Is the method detailed at a later date by Edison practical either electrically or commercially? I unhesitatingly say "No." So far for the system and scientific principle to be followed; now as to a point or two of details. In the Court of Appeal on 31st ult. Lane Fox's patents were lightly touched upon, but they were not "*dealt*" with.

Lord Justice Fry, speaking for himself and Lord Justice Bowen, says the result of this review of all the alleged anticipations of the second claim of Edison's patent of November, 1879, is to convince us that there was no case which brought

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together all the five elements which we have pointed out as combined in Mr. Edison's second claim, carbon in a filamentous form, in a vacuo, and in a receiver entirely of glass through which the leading wires pass.

Now, as Lane-Fox's patents have been touched on by the judge the public will naturally assume that Lane-Fox's patents had little or nothing tending to affect their decision.

The fact is Lane-Fox's patents have been touched on very lightly, but they have not been dealt with.

Now let us see whether these five elements above referred to, viz., *carbon in a filamentous form, in a vacuo, and receiver entirely of glass through which leading wires pass*, did not exist before Edison's patent of November, 1879. It must be remembered that at this date Lane-Fox had been hard at work in his laboratory for some time; his first patents were more than a year old.

Well, prior to this patent of Edison's, Lane-Fox had described exhausting (not refilling again with nitrogen, &c., unless specially desired, his object in putting in nitrogen when he did was to balance atmospheric pressure, and diminish chances of leaking). He had described sealing the wires through the glass bulb, the vacuum and carbon. So far we have four of the five points. *Glass, vacuum, leading wires sealed in carbon.* The only point not touched on is "filament," or filamentous. In order to make the point more striking, let us take Edison's own definition of filament in this very patent. He describes mixing a paste, and cuts his "shuts" or "wires" of carbon from it.

Long before this Lane-Fox had made his bridges, as he called them, usually of horse-shoe form, by moulding under great pressure (certainly a better method than rolling).

Edison describes in his patent ("the" patent) mixing his filament paste with non-conductors to increase the resistance. Lane-Fox had previously done this. Lane-Fox had some time before this even *specified carbonised asbestos*. It appears, therefore, that long before the date of this Edison patent, November, 1879, Lane-Fox had all these five points cited by the judges. It was remarked that there was no evidence that the Lane-Fox lamp ever gave a ray of light. This case was not fought on what Lane-Fox had done. So far as I know there has been no attempt to show what he has done, nor was any Lane-Fox evidence offered.

The Lane-Fox patents were the outcome of hard practical laboratory work, and there is, I imagine, plenty of evidence as to what he did, and that the lamps not only gave a ray of light, but that many lamps were actually made and worked which were just as successful as Edison's made at that period. —Yours, &c., RADCLIFFE WARD.

10A., Great Queen-street, Westminster,
9th February, 1887.

PROPOSED ELECTRICAL TRANSMISSION OF 500 HORSE-POWER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I will be much obliged if some of your numerous readers will give me information on the following subject:—I am interested in a factory driven by water-power, which is so situated that it is impossible to place the mill buildings close to the power, and we are therefore obliged to work with wire ropes. This method of working is inconvenient in some respects, and as it is now proposed to extend the works I am anxious to know whether the power could be transmitted by electricity at a moderate cost. The power required is 500 horse-power, and the distance to be transmitted is about 300ft. vertical and 500ft. horizontal, or, say, about a total of 800ft. The turbines there is no difficulty about, but what is wanted is an approximate idea of the cost of dynamos and cables for the transmission of 500 horse-power, and of the loss of power in transmission. The temperature ranges from about 70deg. to 105deg. In the rainy season the mist from the spray of the waterfall comes over the turbine house, so that the cables would be constantly wet for some months.—Yours, &c.,

ENQUIRER.

REMARKABLE ELECTRICAL ATMOSPHERIC PHENOMENON.

TO THE EDITOR OF THE ELECTRICIAN.

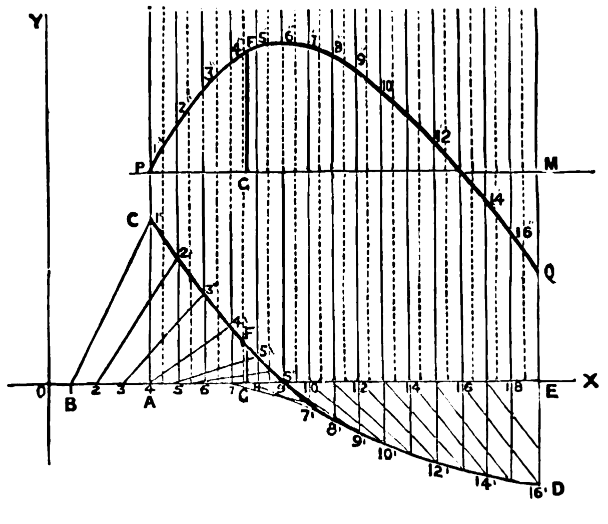
SIR: A peculiar phenomenon took place on the 1st of February, 1887, in Gitomir (Russia). It was at sunset, between 5 and 5:30 p.m. The sky was clear, and the state of atmosphere perfectly calm. Temperature was about freezing point. Condensed vapour, in a somewhat thick fog, stood at the height of 5ft. or 6ft. over the river. Suddenly a ball of electricity ascended, like a rocket, from the river to the sky. The fluid took the form of a red fire-ball (not larger than a bullet); it passed rapidly, almost in a straight line, up into the sky, as far as the eye could reach, leaving behind a perfectly white line, on both sides of which were instantly formed silvery-bluish clouds, which gradually grew bigger and paler, until all (in six or seven minutes) vanished into the air. There was no report or noise of any kind, and it attained the before-mentioned height in about five seconds.

I communicate you this fact, thinking that you will perhaps find it worthy of notice in your esteemed paper.—Yours, &c.,

Gitomir, Feb. 3, 1887. R. GIGNY.

ELEMENTARY NOTE ON GRAPHIC METHODS.

The number of occasions upon which electricians find it necessary or desirable to resort to the graphic method of recording and investigating the results of experiments in which *time* is one of the elements to be considered is very great. The charge and discharge of secondary batteries (both with reference to the current and the work expended), the difference of potential between different points upon the commutator of a dynamo, the periodic variations in the E.M.F., current, and work produced by alternating machines, or by transformers, are all familiar instances of this character. But it frequently happens, especially where measurements of *work* are concerned, that it is desirable to know, not merely the variation of this quantity from moment to moment, but also its total sum from the commencement of a given period—that is to say, we wish to *integrate* the curve of variations. If we knew the value of the integral from moment to moment we could then construct a second curve, which would give us, for instance, a record of the total work done at each instant from the commencement of the experiment.



If the curve be of any regular order, the equation to the second curve can be obtained by integration from the equation to the first. But the object of this note is to draw the attention of non-mathematicians to a simple graphical construction whereby the integral of any curve, however irregular in shape, may be readily obtained to any required degree of approxima-

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tion. This construction is due to M. Zwurko, by whom it was first indicated in the year 1884, and we are indebted for its exemplification at the present time to the publication of a work by M. Abdank-Abakanowicz, entitled "Les Integraphes, La courve integrale et ses applications."

In the figure, let C D be a curve which is required to be integrated, and which we shall assume to be drawn upon squared paper, the perpendicular lines only being drawn in the figure. On the axis X to the left of the ordinate passing through the point C, mark off a number of divisions equivalent to the unit of the scale upon which the figure has been drawn. Let A B be this unit, in this case equal to three divisions. Then draw the series of lines 11′, 22′, 33′, of which the projections upon the axis of X are equal to this unit; or, in other words, draw lines from the foot of each ordinate to the extremity of the third ordinate to the right.

Now, from the point P, upon the ordinate A C, draw a line parallel to 11′, and produce it to meet an ordinate erected at a distance equal to one-half the sub-divisions in the scale (the half distance ordinates are shown in the figure by dotted lines). From the point 1″, thus obtained, draw a line parallel to 22′ to meet the next dotted-line ordinate, and so on. We thus obtain the broken lines P 1″ 2″ 3″.... which will approximate more and more nearly to the true integral curve as the sub-divisions of A B are increased in number.

It may, perhaps, be as well to give an illustration of the interpretation of the new curve before concluding this note. Let C D represent the variation of a current which commences in the positive direction with a value proportionate to C A, and decreases to zero during an interval represented by five horizontal divisions of the scale, and finally attains a negative value equal to E D. Then the curve P Q shows us that at an end of the period represented, say, by A G, the total number of coulombs which have passed in the + direction is proportionate to the height of the ordinate F G. At the end of the period represented by 12 divisions, equal quantities of electricity have passed in each direction, and at the close of the experiment the net result is a transfer of a number of coulombs proportionate to U Q in the negative direction.

CONTEMPORARY PROGRESS.*

ON THE GALVANIC POLARISATION OF LEAD.

By F. Streintz and E. Aulinger, *Wied. Ann.*, Vol. XXVII., 1886.

The question as to what part is taken by each of the plates of a secondary battery in the production and maintenance of the polarisation current has not yet been completely answered, in spite of its important bearing on their construction, as its answer would decide whether both the plates should be of lead or the negative plate of some other metal.

Some method of experimenting had to be found in which each of the acting plates of a secondary battery should be separated by means of a neutral plate. Fuchs's method unfortunately is only applicable in the case of a small E.M.F. in the immediate neighbourhood of the plate whose action is being investigated, for otherwise the effect of the difference of potential between the plates and the adjacent layer of fluid cannot be neglected.

This method was therefore only employed in a few preliminary experiments to determine how much the polarisation was increased by the action of the hydrogen liberated at the negative electrode. Streintz had already found (*Wied. Ann.*, Vol. XVII., p. 841, 1882) that the so-called hydrogen polarisation depends on the nature of the electrodes, being greater, for example, with gold than with platinum electrodes, and considerably less with electrodes of aluminium, and that in the case of metals capable of occluding hydrogen, the greater part of the polarisation continues for some time after the current is broken, while with other metals, such as aluminium, every trace of polarisation disappears very soon after breaking the current.

The lead plates were placed in a vessel containing dilute sulphuric acid, and communicating with a second vessel containing an amalgamated zinc plate in a concentrated solution of sulphate of zinc, by means of a capillary glass siphon of the form shown below, with its end *a* resting against the porous

lead plate under investigation.

The difference of potential between the zinc and lead was found to be about ·75 to ·77 volt; but when all traces of oxide were removed from the lead plate by scraping it fell to ·45 volt.

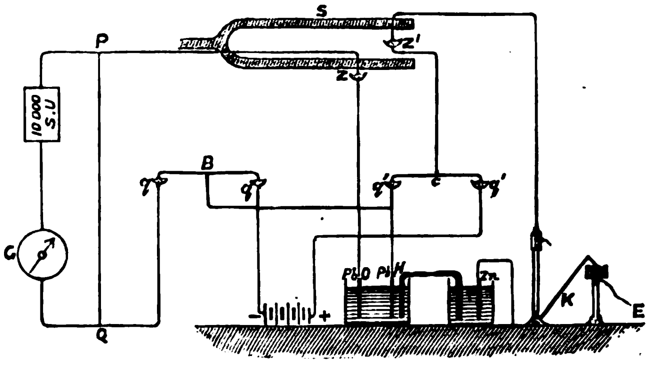
The standard cell used for comparison was Ettinghausen's form of Clark's cell, and the polarising current was obtained from three Daniell cells. As soon as the circuit was closed the lead plate at which hydrogen was being liberated was connected with the earth and also with two quadrants of an electrometer, and the zinc plate was connected with the other pair of quadrants.

Half an hour after starting the current the difference of potential was − ·26 volt, rising in the course of another hour to − ·29, at which it remained steady.

Immediately after breaking the circuit the electrometer reading was + 45 volt, at which it appeared to remain for a considerable time, but after many hours it rose to ·75 volt. These results may be explained by the assumption that so long as hydrogen is being liberated at the lead plate there is an E.M.F. of polarisation between them of ·45 + ·29 = ·74 volt, but that the polarisation ceases when hydrogen is no longer liberated, the lead plate then acting in the same way as one mechanically freed from oxide.

In a secondary battery, therefore, the effect of the hydrogen is to deoxidise the lead plate, and not to cause even a transitory increase in the E.M.F. After this result was obtained Fuchs's method was replaced by the arrangement shown in the accompanying diagram.

One of the lead plates was connected with the positive pole of the battery (three to five Daniell cells or three Bunsen cells) and with the galvanometer. The second plate was connected with the metallic lever B, by means of which it could be connected, through one of the mercury cups, *q*, with either the zinc pole of the battery or the galvanometer.



In the galvanometer circuit was a contact-breaker, consisting of an electrically-controlled tuning fork, making 64 vibrations a second, and carrying on its lower prong a platinum point, which at each depression of the prong dipped into the mercury cup *z*. The galvanometer was of the dead-beat Siemens construction, and the galvanometer circuit enclosed a resistance of 10,000 Siemens mercury units. The cell containing the lead plates communicated with the cell containing the zinc plate by means of a glass siphon filled with distilled water, and closed at the ends by pieces of parchment. The zinc plate and one pair of quadrants of the electrometer were in connection with the earth. The lead plates were connected with the mercury cups q^1, either of which could be connected with

* Compiled and translated by G. W. de Tunzelmann. (Continued from page 110.)

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the insulated metallic lever c, which was in connection with the second pair of quadrants. This lever was connected with a mercury cup z^1, which by means of a platinum point on the upper prong of the fork, communicated with a wire attached to a jointed glass pillar, which, when in the position k, connected the second pair of quadrants to the earth when contact was made at z^1, thereby enabling the potential difference at the moment to be read directly from the electrometer.

Method of Observation.

After the lead plates had been charged for a definite time by the current, the lever B was inverted, and the polarisation current was short circuited through PQ, contact being rapidly made and broken by means of the fork. The cups z and z^1 were provided with a screw adjustment by which they could be raised or lowered, and they were so adjusted that one platinum point broke contact just as the other made it. As long as the polarisation current lasted either lead plate could be tested by altering the lever c. The communication between the lead plate and the electrometer was alternately made and broken by means of the fork. To determine the value of the electrometer deflections, the standard battery, in terms of which the E.M.F. was measured, had one of its poles connected with the earth, and the other with the wire dipping into z^1. The deflections were, as was to be expected, somewhat smaller than when the poles were connected directly with the pairs of quadrants, but the E.M.F. ratio was not altered, and therefore in order to obtain the actual values it was only necessary to connect the standard cell with c. This gave a deflection of about 100 divisions on the electrometer, and as the readings could be made with accuracy to a tenth of a division, the arrangement was sufficiently sensitive. The lead plates were prepared according to Planté's method, and in comparatively large pieces, from which small portions 3·5cm. in length by 2 5cm. in breadth were taken for use in the experiment.

The accompanying table shows the nature of the results obtained :—

T	e	E	C_e	C_E
min.				
0	0·46	2 70	217·0	214·0
C·5	0·44	2·60	186·8	186·9
1·0	0·42	2·57	187 0	189·0
1·5	0·44	—	188·5	188 0
2·0	0·43	2 59	186·8	185·0
2·5	0·45	—	180·2	179·3
3·0	0·46	2 63	168·2	169·0
3·5	0·50	—	159 0	159·7
4·0	0·86	2·67	143·0	133·0
4·5	2·14	—	13·3	11·8
5·0	—	2 70	10·4	9·4

The polarising current from five Daniell's cells was allowed to flow for an hour, and the polarising current was then broken and the polarisation current allowed to flow through a small resistance. Two series of observations were made at intervals of time given in the column T, one series of the values of e, the difference of potential between Zn and Pb + H, and the other of the values of E, the difference of potential between Zn and Pb + O. The column C_e gives the strength, in terms of the galvanometer reading, of the polarisation current in the series e, and the column C_E gives the strength of the current in the series E. It will be observed that the currents were practically the same in each case, so that the two series can be compared directly. $E - e$ gives the E.M.F. of the lead pair, and the table shows that within about five minutes it falls from its initial value of 2·24 volts to about 5 volts.

General Results of the Investigation.

As the oxide-coated lead plate is to be regarded as giving rise to the E.M.F., so the hydrogen-coated plate is the one which causes its diminution.

The pair is charged, not by the deoxidisation of the superoxidised plate, but by the oxidisation of the metallic plate.

While, therefore, the hydrogen set free during the depolarisation is unable to reduce the whole of the oxide on the oxidised plate, the oxygen liberated at the same time is sufficient to cover the other plate with a layer of oxide, and even of superoxide, for except on this assumption, the notable increase in the value of e as the polarisation current dies away would be unaccounted for.

The oxygen increases the E.M.F. of the cell by ·1 volt, but this increase disappears in about half a minute.

The hydrogen, after having completely cleaned the plate, appears to be used up in effecting a partial separation of the oxygen liberated from its union with the lead. Therefore it is that during the first few minutes e increases very slowly—as was found to be the case in some observations with a weaker polarising current than was used for those given in the table—or even, as in the example selected, remains practically steady.

No traces were found of any direct development of E.M.F. by the action of the hydrogen.

ON THE CONNECTION BETWEEN TERRESTRIAL MAGNETIC DISTURBANCES AND SOLAR PHENOMENA.

BY H. WILD, *Comptes Rendus*, Vol. CII., 1886.

In this communication M. Wild gives an account of the remarkable correspondence of some recent observations of solar protuberances made in Paris by M. Trouvelot, and at Cambridge (United States) by M. Trouvelot and by Professor Young, with disturbances in the magnetic declination and horizontal intensity observed by himself at the Meteorological and Magnetic Observatory at Pawlowsk, near St. Petersburg. To facilitate the study of the relations between magnetic disturbances and solar phenomena, which are not as yet so thoroughly determined as the correspondence between the periods of maximum magnetic disturbance and those of maximum sun-spot intensity, the author suggests that astronomers generally would do well to follow M. Trouvelot's example in publishing detailed accounts of whatever observations they may make of sudden changes in solar protuberances. He also suggests, in order to have systematic observations, that magnetic observatories should be supplied with instruments for observing and photographing the sun, so that the observers may always be able to make observations on the sun when special magnetic disturbances occur.

M. Mascart, in presenting M. Wild's communication to the Academy, adds some notes of observations made by M. Moureaux at the magnetic observatory of Parc Saint-Maur, confirming the observations at Pawlowsk. M. Mascart points out that, as the chief magnetic disturbances occur almost at the same instant at all parts of the earth's surface, but with minor local variations, the exact nature of the connection between the magnetic and solar phenomena can only be determined by means of simultaneous magnetic observations at different places at great distances apart, so that we must look to the multiplication of magnetic reading stations, combined with frequent photographic observations of the sun, for the solution of one of the most important problems of terrestrial physics.

M. Mascart also suggests that further attention should be given to the question whether polar auroras, which are usually accompanied by magnetic storms, are also related to solar phenomena.

ON THE MAGNETIC ROTATORY POWER OF CRYSTALS.

By M. CHAUVIN, *Comptes Rendus*, Vol. CII., 1886.

Faraday, in his experiments on the electro-magnetic rotation of the plane of polarisation by various bodies, was unable to obtain any rotation with many substances, and this was the case with all doubly refracting crystals. M. E. Becquerel afterwards succeeded in obtaining rotation in crystals of quartz, and also in some small crystals of beryl and tourmaline, and the phenomenon in the case of quartz has since then been more fully investigated by other observers. A large number of crystals are, however, still supposed to produce no rotation, and for none had a complete investigation been hitherto made.

M. Chauvin therefore determined to take up the inquiry, and in the present communication he describes the results he

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has obtained with Iceland spar, which he selected for his first experiments, as, according to Wertheim, it would be the most unlikely substance to show any rotation, on account of its pre-eminent power of double refraction.

The apparatus used was a Laurent saccharimeter, modified by placing the semi-circular slice of quartz, cut parallel to the axis, and of a thickness equal to half the wave length of light employed, between the crystal and the analyser, in order that the light falling on the crystal should be plane polarised.

A Drummond light was used as the source and was made sensibly homogeneous by passing through a solution of bichromate of potash or sulphate of nickel. The slit was made extremely narrow and was placed horizontally. The crystal was placed between the poles of an electro-magnet, and could be moved either about a horizontal or a vertical axis. The polariser and analyser being adjusted to produce extinction, and one arm of the cross remaining horizontal when the crystal was turned about a vertical axis, the semi-circular slice of quartz was placed in position and turned until the luminosity of the field was uniform.

The analyser was then turned through a small angle with regard to the axis of the slice of quartz. The smallness of this angle determines the sensibility of observation.

Some of the results obtained with a piece of spar 36mm. in thickness are given in the accompanying table, in which θ is the angle of inclination of the axis of the spar (varied by turning the crystal about the horizontal axis), ϕ_1 is the corresponding rotation with 5 Bunsen cells, and ϕ_2 with 10 cells.

The values of ϕ are the means of observations with the current in opposite directions:—

θ	ϕ_1	ϕ_2
0′	1° 45′	2° 15′
5′	1° 40′	2° 9′
15′	1° 24′	1° 44′
25′	1° 6′	1° 2′·5
35′	24′·5	31′·5

With θ greater than 35′ there was no perceptible rotation.

MEASUREMENTS OF THE ELECTRICAL CONDUCTIVITY OF POTASSIC CHLORIDE.

By E. Bouty, *Comptes Rendus*, Vol. CII., 1886.

In previous researches on the electrical conductivity of saline solutions, the author had used solutions of potassic chloride as standards of comparison, and was therefore desirous of obtaining a series of accurate determinations of the resistance of solutions of this salt of various strengths and at different temperatures.

He first determined, in absolute measure, the specific resistance of a standard solution of potassic chloride, containing 74·59 grammes (one equivalent) to the litre. The resistance of this standard solution was then compared with that of solutions of various strengths at temperatures ranging from 0° to 30°.

Absolute Measurements.

A spiral capillary tube, terminatin at each end in a funnel, was successively filled with pure mercury, and with the standard solution at 0°. The resistance of the mercury was then determined in legal ohms by the Wheatstone bridge method, and that of the solution by means of an electrometer, and the specific resistance of the solution was found to be 15·415 ohms, a result which could be relied on to within 1 per cent.

Comparative Measurements.

Three methods have been used for measuring the resistance of liquids, viz.: (1) The method of alternating currents; (2) Paalzow's method, which consists in eliminating the polarisation of the electrodes by the use of zinc electrodes in a concentrated solution of sulphate of zinc; (3) the electrometric method. In a former research, the author found that the first method was greatly inferior in accuracy to the third in the case of very dilute solutions.

With regard to Paalzow's method, the author finds that the polarisation of the electrodes is completely eliminated when the resistance of the portion of the circuit containing the electrolyte exceeds 10,000 ohms, and it has the advantage of allowing the measurements to be made very quickly, but when the resistance is as much as a megohm, the results can only be relied on to within 10 per cent., owing to the impossibility of making the galvanometer sufficiently sensitive, while the electrometric method can be relied on to within ½ per cent. for even greater resistances. The latter method was therefore used for the measurements.

The chief difficulty was found to be the exact determination of the temperature—the greatest accuracy being required—as a variation of 0°·1 in temperature caused a variation of ·003 in the resistance.

The capillary tubes were therefore plunged during the measurements in baths of such a size that the variation of temperature during an experiment was insensible, and thermometers were used reading to the tenth of a degree.

Results.

Between 0° and 30° the resistance of the solutions was found to be given to a close approximation by the formula—

$$r_t = \frac{r_0}{1 + at}.$$

In the following table, N is the number of equivalents of the salt in solution, r_0 the specific resistance at temperature 0°, ρ_0 the molecular resistance compared with that of the standard solution, and a the value of the constant in the above formula corresponding to different values of N:—

N.	r_0	ρ_0	a.
3	5·172	1·007	·0230
2	7·785	1·010	·0259
1	15·415	1·000	·0291
0·5	30·49	0·989	·0302
0·2	72·23	0·937	·0326
0·1	141·0	0·915	·0327
0·01	1325	0·860	·0333
0·001	12697	0·824	·0333

MAXWELL'S THEORY OF ELECTRICITY.

It is, perhaps, a matter for some regret that the marvellous mechanical concept of electric action which we owe to the genius of Clerk-Maxwell should up to the present time have entered so very little into the mode of thought of the practical electrical engineer. It is true that the "Treatise on Electricity" cannot be read with advantage except by those who possess a very fair acquaintance with the higher mathematics; but there is no reason why the mechanism of the system which Maxwell conceived as capable of producing effects analogous to those of electricity should not become familiar to every practical electrician. Whether this system does or does not represent the ultimate conditions of nature, we entertain no doubt that a more general familiarity with these conceptions among *practical* men would prove helpful to the advance of applied science.

For the substance of the following article we are largely indebted to the account of Prof. Maxwell's scientific work which appeared in the first edition of the admirable "Life of Clerk-Maxwell," by Prof. Lewis Campbell and Dr. Wm. Garnett (Macmillian and Co.). From the second edition the whole of this account has been omitted, as it does not appear to have suited the taste of the general reader. It is, however, far too good to be lost, and the first edition having for some time been out of print, there is an additional reason for reproducing the substance of this chapter in our columns. We have also made some use, in the introductory paragraphs more particularly, of an article by M. Seligmann-Lui, which appeared some time ago in the *Journal* of the International Society of Electricians.

At the period when the methods of the calculus were first applied to the study of electricity the idea of action at a dis-

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tance was accepted without hesitation—that is to say, in virtue of some property assumed to be inherent in matter it was admitted that the mere presence of one body could exercise a material influence upon another from which it was separated by absolutely vacant space. It was upon this hypothesis that the splendidly successful mechanical theory of the Heavens had been raised, and it was natural that the mathematicians, finding at the very basis of the science of electricity a law of attraction altogether similar to the Newtonian law of gravitation, should seek to apply to this new case the principles and the methods which had already yielded such admirable results in the study of astronomy. The earlier researches, and particularly those of Poisson, had then for their point of departure the law of Coulomb, and the hypothesis of an action at a distance exercised in virtue of some special fundamental property of matter.

But as the facts observed did not permit the special property to be attributed to ordinary matter, they made it a characteristic of a hypothetical "imponderable fluid" existing permanently in the interior of ponderable matter, and manifesting its presence under certain conditions by this special property and by the various consequences which may be deduced therefrom. The study of magnetism was approached in the same spirit and by the same methods. It was easy even at that time, from a philosophical point of view, to find fault with the introduction of embarrassing hypotheses of this nature. On the other hand, we must remember that the explanation of the phenomena of light depends upon the supposition that space is filled with a fluid essentially distinct from tangible matter, whose movements propagated from the source of luminosity produce upon our eyes the sensation of light, in the same way that sound is conveyed by the air from the vibrating body to the ear. In fact, each branch of physics at that time appeared to demand its appropriate medium of transmission, but the difficulties of effecting a co-ordination among the sciences were thereby proportionately increased and intensified, and instead of recognising in the phenomena of nature the operation of one organic system, the various orders of phenomena were classified in narrow and exclusive categories which admitted of no further generalisation.

Faraday was one of the first to combat these tendencies; he refused to admit that a body could produce any effect in a place where it was not, unless by the aid of intermediate agents, which latter could only be found in the intervening medium. Without attempting any explanation of the nature of electricity, he refused to consider an electrified body as being isolated in space in the presence of other bodies, and connected with them only by some occult, mysterious "property." On the contrary, he figured to himself the existence of lines of force, varying in number and in form, according to circumstances (invisibly prolonging, as it were, the limits of the bodies), throwing themselves across the field, and becoming attached to the bodies which were either attracted or repelled. But these lines in Faraday's system are to be considered merely as a geometrical abstraction, useful for mapping out space, but incapable of determining mechanical motion, and they are not to be conceived as entities having a veritable substantial existence. The active cause of the observed movements must be sought in the medium which separates the electrical conductors, and it was shown that the phenomena of attraction could be explained on the supposition that electrification determined in this medium a condition of stable equilibrium characterised by a tension along the lines of force, and an equal pressure in all transverse directions. But the question remains, what ought we to understand by this medium? Faraday himself suggested the direction in which an answer might be sought. The famous experiment of the magnetic rotation of the plane of polarisation revealed an interdependence between optical and electrical phenomena, and gave colour to the assumption that the luminiferous ether was also itself the medium of the transference of electro-magnetic force.

In order to complete the great work of Faraday, three steps remained to be taken: (1) To establish by some general demonstration the fact that all the phenomena hitherto explained upon the assumption of action at a distance were capable of equally complete explanation upon the theory of propagation; this was very readily accomplished by Maxwell (*Camb. Phil. Trans.*, 1856). (2) By further experiments to render still more probable the identity of the luminiferous ether with the vehicle of electro-magnetic action; in this direction many *savants*, including Maxwell himself, have obtained valuable evidence, though doubtless much still remains to be done. (3) And lastly, to conceive the mechanism of propagation, and from this hypothetical structure to deduce all the known phenomena of electricity, and thence again to establish the necessary connection with the phenomena of light; it is this last work with which is permanently connected the name of Maxwell. We proceed to reproduce in summary the principal features of his system.

The undulatory theory of light, it will be remembered, upon experiments altogether independent of electrical phenomena, requires the existence of a general medium, of very low but yet finite density, capable of being set in motion and of transmitting this motion with an extremely great, but yet a finite and measurable velocity. The movements of this medium imply the existence of kinetic energy, and its elastic deformations the existence of potential energy.

We must now postulate that from the principle of inertia it follows that a body when revolving around a fixed centre tends at each instant to get further away from that centre, and therefore it develops a tension in any connecting medium by which it is constrained to follow a circular orbit. This tension will be directed along the radius, and its amount will depend upon the velocity with which the body moves and the distance of the body from the centre. It follows from this that a rotating body tends to contract along the axial line, and to extend itself upon the equatorial plane. From the principle of the conservation of angular momentum, it also follows that in a body rotating upon an axis at a given velocity, and which is not submitted to the action of any external force capable of altering this velocity, all changes in the distribution of the material due to any internal cause, and which effect any modification in the moment of inertia of rotation, determine also a modification in the inverse sense of its angular velocity. This much being postulated the hypothesis of Maxwell is as follows:—

The medium capable of transmitting the magnetic force consists of a very great number of spherical bodies or cells, susceptible of rotation, the which, under the influence of the magnetic force, take, around the lines of force as axes, a movement of rotation, of which the velocity and the sense depend upon the intensity and the sense of the force.

In order to fix our ideas we shall assume that this direction is always in the sense of a right-handed screw advancing in the direction of the lines of force.

Magnetic Action.—The magnetic field is thus imagined as being filled with whirling molecules, which turn all in the same sense, and by reason of their rotation are contracted in the direction of their axis, so that the tension of the medium follows the lines of force. For the same reason the molecules are dilated in their equatorial planes, thereby producing pressure in the medium throughout these planes.

When two poles of contrary name are opposed to one another, the lines of force proceed from one to the other in certain well-known curves, and the approximation of the lines, or the number passing through unit area, gives the measure of the magnetic force; thus the simple inspection of the curves (produced in the usual way, by means of iron filings), serves to show that this force is greatest in the line joining the poles and in its vicinity. It is therefore in this part of the field that the rotation of the molecular whirls is most rapid, and that the tension of the medium along the lines of force is greatest. Thus we find the explanation of the apparent attraction of the poles. The potential energy of each pole is in reality due to the kinetic energy of the molecular whirls, and the energy therefore resides, not in the poles themselves, but in the interposing medium. If the dimensions of the field diminish by the approach of the poles, the velocity of the whirls augments, but the total energy of the field diminishes by a quantity corresponding to the work done by the approach of the poles. Similarly, if two poles of the same name are

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placed near together, the lines of force do not pass from one to the other, but deviate laterally, and the transverse pressure of the whirls determines the apparent repulsion.

Electric Currents and Electro-Magnetic Induction.—But the question next arises, By what mechanism is the movement of rotation transmitted in the same sense from one molecular whirl to the following? Maxwell supposes *that there exist certain extremely small spherical particles placed between the cells, which, rolling without sliding upon their surfaces, effect the transmission of rotation from one molecule or cell to the other without inverting its direction*, playing the part, in fact, of idle wheels. These particles may be said to constitute electricity itself; they are of excessively small dimensions in comparison with the size of the cells, while these again are excessively small when compared with the molecules of ponderable matter. In an insulating medium or dielectric it is supposed that the electric particles are unable to pass from molecule to molecule of the body; but in a conductor they can do so, the passage, however, being opposed by friction, so that heat is generated and energy dissipated in the process.

When a current circulates in a conducting wire, these electric particles are animated by a movement of actual translation. Consider the particles which lie in the central line; each particle in rubbing against the cells by which it is environed exerts upon them a tangential force, and thus sets up a series of annular whirls, of which the axis of figure is directed in the line of trajectory of the particles, and the rotation is effected in the diametral planes.

Each ring of whirls or vortices will, in fact, behave like an india rubber umbrella ring when we pass it over a stick. Instead of sliding into its place it proceeds by a rolling motion, continually turning itself inside out, as it were, each circular section of the ring rotating about its own centre.

This whirl reacts in its turn by friction upon the adjoining particles, and tends to drive them in the direction *opposed* to that of the central line of particles. In order that these particles may remain unmoved, it would be necessary that they should be acted upon at the opposite extremity of their diameters by a second concentric annular whirl, having a velocity equal to that of the first; for then these two tangential forces, being equal and contrary, would form a couple, and the particle would be turned around its centre without either advancing or receding. Thus, in order that these particles may advance *in the same direction as those in the centre* (which under our hypothesis is the same thing as saying that a current of electricity is set up in the wire) it is necessary that the second annular whirl shall exercise a tangential force greater than that of the first—that is to say, it must turn more quickly. Proceeding outwards through the section of the wire until we arrive at the surface of the conductor, we shall pass though a series of concentric cellular rings, all having the same axis of figure, and rotating in the same sense, but animated by a progressively increasing velocity. Such ought to be our conception of a conductor traversed by a current.

At the surface of the wire, the last whirl reacts upon the nearest particles of the dielectric, and, therefore, through these upon the whole of the medium, and thus throughout unlimited space it sets up a series of annular whirls of continuously increasing diameter. If the cells present a certain elasticity, and, in consequence, do not commence to obey the tangential forces until they have undergone a certain deformation, the movement, or, in other words, the electro-magnetic induction, is not propagated instantaneously; but the velocity of transmission will depend upon the density and the elasticity of the cells of the dielectric. We shall presently see what is the measure of this velocity.

Direction of the Electro-Magnetic Force and the Law of Ampère.—For the sake of simplicity, we will confine our attention to the case of a rectilinear current. The direction of the magnetic force created by a whirl, and the sense in which the latter rotates, are, by our hypothesis connected by a right-handed relation—that is, the direction in which we turn a corkscrew to insert its point. It results from this that the sense of the current and the magnetic rotative force which is due to it are also connected by a right-handed relation. This we know to be confirmed by experience.

In the second place, the medium ought at each point to be submitted to a tension following the direction of the lines of force—that is to say, following the axes of rotation of the whirls; and to a pressure along the transverse planes—that is to say, in a plane passing through the wire.

(To be continued.)

THE ELECTRIC LIGHTING ACT (1882) AMENDMENT BILL.

The following is the text of a Bill, intituled "An Act to Amend the Electric Lighting Act, 1882," introduced in the House of Lords this week by Lord Thurlow:—

Be it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

1.—Section twenty-seven of the Electric Lighting Act, 1882, is hereby repealed, and in lieu thereof the following provisions shall have effect; that is to say:

Where any Undertakers are authorised by a Provisional Order or special Act to supply electricity within any area, any local authority within whose jurisdiction such area or any part thereof is situated may, within six months after the expiration of a period of forty-two years, or such shorter period as is specified in that behalf in the application for the Provisional Order or in the special Act, from the date of the passing of the Act confirming such Provisional Order, or of such special Act, and within six months after the expiration of every subsequent period of ten years, or such shorter period as is specified in that behalf in the application for the Provisional Order or in the special Act, by notice in writing require such undertakers to sell, and thereupon such undertakers shall sell to them their undertaking, or so much of the same as is within such jurisdiction, upon terms of paying the then market value of the goodwill of the business of the undertaking and of all lands, buildings, works, materials, and plant of such undertakers suitable to and used by them for the purposes of their undertaking within such jurisdiction, such value to be in case of difference determined by arbitration. Provided that the value of such goodwill, lands, buildings, works, materials, and plant shall be deemed to be their fair market value at the time of the purchase, due regard being had to the nature and then condition of such buildings, works, materials, and plant, and to the state of repair thereof, and the suitability of the same to the purposes of the undertaking, and, where a part only of the undertaking is purchased, to any loss occasioned by severance, but without any addition in respect of compulsory purchase. The Board of Trade may determine any other questions which may arise in relation to such purchase, and may fix the date from which such purchase is to take effect, and from and after the date so fixed, or such other date as may be agreed upon between the parties, all goodwill, lands, buildings, works, materials, and plant so purchased as aforesaid shall vest in the local authority which has made the purchase, freed from any debts, mortgages, or similar obligations of such Undertakers, or attaching to the undertaking, and the powers of such Undertakers in relation to the supply of electricity under this Act or such Provisional Order or special Act as aforesaid within such area or part thereof as aforesaid shall absolutely cease and determine, and shall vest in the local authority aforesaid.

2.—Notwithstanding anything in the last preceding section contained, the Board of Trade may by any Provisional Order to be made by them under that Act, if they think fit, vary the terms upon which any local authority may require the Undertakers to sell, and upon which the Undertakers shall be required to sell to such local authority their undertaking or so much of the same as is within the jurisdiction of such local authority under the said section in such manner as may have been agreed upon between such local authority and the Undertakers.

3.—(1.) Where in any case any electric line or other work may have been laid down or erected in, over, along, across, or under any street, for the purpose of supplying electricity, or may have been laid down or erected in any other position for such purpose in such a manner as not to be entirely enclosed within any building or buildings, or where any electric line or work so laid down or erected may be used for such purpose otherwise than under and subject to the provisions of a license, order, or special Act, the Board of Trade, if they think fit, may, by notice in writing under the hand of one of the secretaries or assistant secretaries of the Board of Trade, to be served upon the body or person owning or using or entitled to use such electric line or work, require that such electric line or work shall be continued and used only in accordance with such conditions, and subject to such regulations for the protection of the public safety, and of the electric lines and works of the Postmaster-General as the Board of Trade may by or in pursuance of such notice prescribe, and in case of non-compliance with the said regulations then the Board of Trade may require such body or person to remove such electric line or work, provided that nothing in this sub-section shall apply to any electric line or work laid down or erected by any body or

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person for the supply of electricity generated upon any premises occupied by such body or person to any other part of such premises.

(2.) Where in any case any electric line or work is used for the supply of electricity in such a manner as to injuriously affect any telegraphic line of the Postmaster-General, or to affect the telegraphic communication through any such line, the Postmaster-General may, by notice to be served upon the body or person owning or using, or entitled to use such electric line or work, require that such supply be continued only in accordance with such conditions and regulations for the protection of the telegraphic lines of the Postmaster-General and the telegraphic communication through the same as he may by or in pursuance of such notice prescribe, and in default of compliance with such conditions and regulations the Postmaster-General may require that the supply of electricity through such electric line or work shall be forthwith discontinued. Provided that nothing in this sub-section shall apply to the supply of electricity through any electric line or work laid down or erected under and subject to the provisions of any license, order, or special Act, or which may be used in accordance with any conditions or regulations prescribed by the Board of Trade by or in pursuance of any notice given by them under this section.

(3.) If any body or person fails to comply with the requirements of any notice which may be served upon them or him under this section, such body or person shall be liable to a penalty not exceeding twenty pounds for every such offence, to be recovered summarily; and any court of summary jurisdiction, on complaint made, may make an order directing and authorising the removal of any electric line or work specified in such notice by such person and upon such terms as they may think fit.

(4.) Any notice authorised to be served under this section upon any body or person may be served by the same being addressed to such body or person, and being left at or transmitted through the post to any office of such body, or the usual or last known place of abode of such person, and any notice so served by post shall be deemed to have been served at the time when the letter containing the notice would be delivered in the usual course of post, and in proving such service it shall be sufficient to prove that the letter containing the notice was properly addressed and put into the post.

(5.) In this section terms and expressions to which by the Electric Lighting Act, 1882, meanings are assigned shall have the same respective meanings, provided that the term "street" shall include any square, court, or alley, highway, lane, road, thoroughfare, or public passage or place whatever, and the expression "telegraphic line" shall have the meaning assigned to it by the Telegraph Act, 1878.

(6.) Nothing in this section shall apply to any electric line or work of the Postmaster-General, or to any other electric line or work used, or to be used solely for telegraphic or telephonic purposes.

4.—This Act may be cited as the Electric Lighting Act, 1887, and the Electric Lighting Act, 1882, and this Act shall be read and construed together as one Act, and may be cited together for all purposes as the Electric Lighting Acts, 1882 and 1887.

ELECTRIC MOTORS IN THE UNITED STATES.

A correspondent in New York sends us a copy of a circular which has recently been issued by the Sprague Electric Railway Company containing the estimate which we print below. Upon the face of it, an estimate of this kind is avowedly "in the air," and a minute criticism would be absurd. At the same time, without being hypercritical, we may point out that the Sprague Company calculate their revenue upon the basis of the actual *brake horse-power of the steam engine* (plus an additional 50 per cent., which experience has shown may safely be sold in excess of the output at a given time), and it would appear from this that not only do the Sprague dynamos and motors each show a commercial efficiency of 100 per cent., but also that the company is in a position to distribute power without loss in the mains. We may also add that in New York the value of one horse-power per annum is usually taken at from $40 to $70, instead of $125 as here estimated.

Nevertheless, so far as we can judge, the future of the electrical distribution of power in the United States seems to be perfectly well assured, and it is therefore the more to be deprecated that a powerful company should put forward statements which, to say the least, appear to be open to severe criticism. It is, however, fair to add that the circular appears to have been prepared for electrical firms and companies, and not for the outside public:—

"ESTIMATE OF THE COST OF SUPPLYING ELECTRIC POWER FROM A STATION ALREADY ESTABLISHED, AND THE PROFITS THEREFROM.

We will assume the station to be already in running order, and furnishing lights for both day and night service, and to be of the capacity of 150 horse-power.

Owing to the intermittent use of power by consumers, so well known to steam-power producers, if the power delivered to any one consumer be limited to, say, 10 horse-power, at least double the output of the engine, or 300 horse-power, could be sold from this plant, were it transmitted by the ordinary methods, and, as the loss in transmission by wire is not nearly as great as by belting and shafting, especially where the distance exceeds 100ft., the same law of general average is truer in the case of electric power than in that of steam. We, therefore, could base our calculations upon the well known practice of all power producers; but to avoid any possibility of dispute, we will assume that only 50 per cent. above the actual output of the engine can be sold.

Investment:—	
Additional wires, structures and switches	$2,500.00
Running Expenses:—	
Coal (cheap fuel, three tons screenings to one ton Cumberland), four pounds per horse-power per hour, 10 hours per day	$2,200.00
Oil (additional)	100.00
Motor inspector (can also attend to lamp inspection)	500.00
Water, incidentals, &c.	200.00
Other expenses which cannot be specified	500.00
Total	$3,500.00
Profits:—	
Income from two hundred and twenty-five horse-power at $125.00 per horse-power per annum	$28,125.00
Less expenses, per annum	3,500.00
Profits	$24,625.00
Income from two hundred and twenty-five horse-power at $100.00 per horse-power per annum	$22,500.00
Less expenses per annum	3,500.00
Profits	$19,000.00

Where the station is only running during the night, the profits are the same as above, after first deducting the additional expense for engineer and fireman for day service, but as all incandescent plants to be a complete success must be run during the day, and as such has been the experience of so many plants, it hardly needs mention, and the additional profit from the day lighting will, in almost every instance, more than cover the extra expense.

SMALLER PLANTS.

In small cities and towns, where not more than one hundred horse-power can be sold within a reasonable time, it is often considered advisable for the company to own the motors, and as the intermittent use in such small plants will not be so great, we will assume that only the output of the engine can be sold. The investment and profits therefrom would be as follows:—

Investment:—	
Motors, various sizes, up to 10 horse-power and agregating 100 horse-power	$10,000.00
Wires, structures, and switches	1,000.00
Total investment	$11,000.00
Running Expenses:—	
Coal (as above)	$1,550.00
Oil (additional)	50.00
Inspector (lamp inspector for small plant can attend to motor inspection)	500.00
Water, incidentals, &c.	150.00
Other expenses which cannot be specified	500.00
Total expenses	$2,750.00
Profits:—	
Income from one hundred horse-power at $125.00 per horse-power per annum	$12,500.00
Less expenses	2,750.00
Net profit	$9,750.00
Income from one hundred horse-power at $100.00 per horse-power per annum	$10,000.00
Less expenses	2,750.00
Net profit	$7,250.00

The figures as given above for expenses are not theoretical, but are founded upon the actual expenses of running electric light and motor stations, using Armington and Sims engines and the Jarvis setting for boilers."

We may add that our correspondent throws some doubt upon the literal accuracy of the statement in the last paragraph.

THE ELECTRIC LIGHT INDUSTRY IN AMERICA IN 1887.*

"The rapid development of the electric light industry is beginning to attract the attention it merits. When nearly every one of the local companies already established is increasing its plant, and when new companies are organising at the rate of ten or fifteen a week, it is safe to assume that the industry is on a solid basis and has a great future. The only element of instability that I can see lies in the certainty of great and even radical improvements in lamps and methods of distribution. Such instability is desirable. From dynamos, however, giving 90 to 95 per cent. efficiency, little more can be hoped or asked.

"I believe no figures are extant as to the magnitude of the industry and the value of the investment in it. Indeed, where growth is so rapid and widespread, it is difficult to follow it up and keep the record complete. But there is data from which a very near approximation can be made. At the present time about forty 'parent' companies are supplying dynamos and lamps, in most cases both, and many of them furnish incandescent as well as arc apparatus. In addition to these we have a total of from 650 to 700 local electric

* By Mr. T. C. Martin, in the *Electrical World* of New York.

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lighting companies at work to-day in America. Moreover, the gas companies have in a most remarkable manner evidenced their appreciation of the electric light—by undertaking themselves to supply it. At the beginning of 1886 a score of gas companies were operating electric lights. The number now is at least double. This feeling on the part of the gas companies, too, is only just at the outset of its manifestation." Figures are then given which bear out the estimate that the total number of arcs now burning nightly in America is at least 140,000.

"In order to get at some approximate idea of the outlay on these lights, a 50-light unit may be taken, as that would represent the maximum size of by far the larger number of plants of all kinds. Plants to-day often cost from one-half to one-third less than they did two years ago, but an average of $15,000 per plant, of 50 lights, complete—*i.e.*, inclusive of plain lamps, dynamos, all regulating apparatus, engines, boilers, smoke-stack, and the like would be near the mark; and though street wiring, in the case of central station work, might be put at say $300 a mile, the figure will serve, in the gross, as well for central as for isolated lighting. Such a basis of calculation yields the sum of $42,000,000 actual investment in arc lighting apparatus.

"The increase in the incandescent lighting business has been equally phenomenal; the growth of the Edison system, for example, under its present management has been simply tremendous. There were in August last 702 isolated Edison plants, with 181,463 lamps.

"At the same date, in 1886, there were 58 Edison central stations, with 149,900 lamps. This makes a total of 331,663 lights. The increase has been maintained, as, when returns were taken just before the close of the year, the total was over 387,000, or, if the lamps actually placed in isolated plants were taken instead of the mere dynamo capacity, we get a total of over 500,000 Edison lights in use in America.

"The other incandescent companies make also a notable showing, and the statistics indicate that they have placed at least 130,000 to 150,000 lamps—the Westinghouse Company, for instance, organising a dozen central stations, with some 15,000 lamps, in the last year, to say nothing of isolated work.

"As a basis of estimate, therefore, it should be fair to take 550,000 incandescent lamps. The cost of complete installation, for both central and isolated work, may be put at from $25 to $30 per light, according to circumstances. This gives, at $25, an investment of $13,750,000.

"A great many of the arc and incandescent companies have built their own stations. The value of the property employed and owned by the companies, between 600 and 700, may be put at $10,000,000. It is by no means unusual for $15,000 to $25,000 to be spent on a station building.

"In the manufacture of arc lighting apparatus large sums of money are invested. One company alone has a capital of $3,000,000. It would, therefore, be moderate to put the twenty parent arc companies at a total value of $15,000,000. The parent incandescent companies are placed low at $10,000,000. Next to be considered are the carbon manufacturers, whose business has increased marvellously, from the fact that their product is one of daily consumption. The twelve concerns active in the business would probably capitalise at $10,000,000. Then come the makers of fixtures, globes, towers, poles, mast-arms, &c., representing another $10,000,000. A very large proportion of steam engineering relates now to the industry very directly, in engines, boilers, heaters, pumps, gauges, belts, and the like, valuing at another $10,000,000 capitalisation; and it is not to be forgotten, under this head, that over 15,000 horse-power are derived from turbines for electric lighting purposes. The capitalisation of the wire and cable manufacturers, of underground material and conduits, of switches, tools, and the various necessities of a dynamo room would reach at least $20,000,000. And last come the patents.

"Of these the Edison Company alone has more than 300, while other leading companies are similarly equipped. During 1885 over 400 patents were taken out of direct bearing on electric lighting. The cost and value of all electric lighting patents may be put at $10,000,000.

"I have so far taken into account only such investments and capitalisations as belong to the industry, within the narrowest limits. Nothing is allowed, for example, for testing instruments, buggies and horses for patrolling lines, office furniture, and other items which are essential to the work, and which, though perhaps small in each case, tell up when taken in mass for several hundred companies. Nor is any allowance made for the various electric motor companies, with a capital of several millions, running over 5,000 motors and at least a dozen street railways.

"The total of investment and capitalisation comes out thus:—

Direct investment in local arc lighting	$42,000,000
„ „ „ . incandescent lighting	13,750,000
Real estate	10,000,000
Capital value of arc lighting manufacture	15,000,000
„ „ of incandescent „	10,000,000
Capital value of carbon manufacture	10,000,000
Capital value of manufacture of fixtures, globes, towers, poles, mast-arms, &c.	10,000,000
Capital value of manufacture in steam engines, boilers, heaters, pumps, turbines, gauges, &c.	10,000,000
Capital value of manufacture of bare and insulated wire, cables, underground material, conduits, switches, tools, &c.	20,000,000
Value of patents	10,000,000
Grand total	$150,750,000

"That is to say, an industry too insignificant for the serious attention of the last census returns now represents cash value, roundly, of $150,000,000, not on the basis merely of capital stock but of actual investment, manufacturing plant, and good-will. I am not aware that any one of the above items can be considered excessive. The doubt is admissible whether the estimates do not fall short of the mark."

COMPANIES' MEETINGS & REPORTS.

The Anglo-American Telegraph Company (Limited).

The half-yearly general meeting of this Company was held on the 4th inst., at Winchester House, Old Broad-street, Viscount Monck presiding.

The notice convening the meeting having been read by the Secretary,

The CHAIRMAN said: It is now my duty to move the adoption of the report, and in doing so let me previously express to you my regret that we are not able to bring before you a more palatable bill of fare than we disclose in the report. Gentlemen, I will not on the present occasion trouble you with any comparison of receipts for the past year; the change in the rate of tariff would make the comparison entirely illusory and useless. If you look at the accounts you will see that the difference between the expenditure this year and last year is very trifling. It is rather larger this year than last, but that is the result of our having to carry a larger traffic, about which I shall have something to say presently. During the last half year we have had the misfortune to have a break in the St. Pierre cable—the old French cable—the oldest cable we have in existence. The break has occurred in very deep water, and will involve a considerable operation in repair. At this time of the year it will be useless to attempt it, and therefore I shall not say any more about it, except that we shall use our best efforts to repair it, and I hope we may be successful. Gentlemen, there came upon us at the end of the year, on the 31st Dec., like a thunderbolt, a notification from our partners, the French Atlantic Cable Company, that they did then and there terminate—the agreement with us under which we have been working for several years past, and under which they have derived a very great advantage—beyond anything which they brought into our pool. Now, gentlemen, I confess our surprise at such a thing being done; it seemed to be so contrary to their own interests; but I believe they do not themselves deny it that this notice was served under the influence and to suit the purposes of the Commercial Cable Company. We believe that they have no right legally by the laws of France, or by the laws of England, to take the step they have taken. They assert it is in consequence of pressure on the part of the Minister of Posts and Telegraphs in the French Government, but they had been working for years under this agreement with the full assent and concurrence of the Minister of Posts and Telegraphs of France [Mr. BURT: "For over six years"]. I am reminded that for six years we have been working under this agreement with the full assent of the French Government, and therefore we cannot admit they have a right to turn round now and upset all the arrangements we have made with them. We are, therefore, at present taking the best legal steps we can to assert what we believe to be our rights, and to meet this attack, as I may call it, of the Commercial Company. Gentlemen, that being the case, I had better not say much more about it, except to tell you the simple facts, because they are now in the hands of our legal advisers, and I have no doubt, with your experience of our legal advisers, you will know that your interests will be sufficiently attended to. Well, gentlemen, I now come to what is really the crucial point of the day, and that is the competition which is still going on for the traffic with America. I would wish to recall your attention to the circumstances as they stood at our last general meeting. Previous to that meeting, the Commercial Company had opened their cable for traffic. Their first step was to reduce the tariff from 2s. to 1s 8d. per word. The effect of this was simply to reduce the rates without, in any degree, increasing the volume of business. We endeavoured to work for some time on that tariff, but we found it so disadvantageous (it is not necessary to go into other reasons now) that we were obliged to abandon it, and when we came to abandon that tariff we had to reconsider our whole policy. Hitherto, on the opening of competition we had endeavoured, by arrangements, to maintain our tariff, hoping thereby to retain our revenue, but we found that that mode of proceeding had really the effect of attracting further competition into the field. It is a most curious thing. It seems as if telegraphy across the Atlantic has some sort of fascination for capitalists. Although they see that the companies that already exist are making very small dividends—(A Voice: "None at all")—well, none at all, but I am talking now of the past, they had been making very small dividends, the enterprise was a most risky one, and it involved a very large outlay—yet they seemed by some extraordinary fascination to be attracted to put further capital into the business, and to create further competition, thereby largely injuring the existing companies without in the slightest degree benefiting themselves. Well, gentlemen, we reconsidered our whole position, and we came to the conclusion that the only policy we could adopt in the face of what was going on was the policy of going to a low rate, with the view of stimulating and increasing the traffic so as to give us a moderate dividend, which would not serve as an attraction to other people to enter into further competition. We therefore reduced our tariff to 6d. a word. When we came before you with that proposition I told you it was an entire reversal of the policy we had hitherto pursued, and I told you at the same time it was a policy which would make large demands upon your forbearance and patience. We have now been carrying out the 6d. a word tariff for something like nine months and the result has been a very considerable increase in the volume of business transacted. Of course, when you think that our reduction was really a reduction of three-fourths of the cost, it must take a considerable time, even if the time ever arrives, when the loss caused by the reduction will be made up by the increase of traffic; but we may hope that if trade improves, and things in general get better, we shall participate in the improvement, and that traffic at a low rate may become the normal price of traffic across the Atlantic. That, gentlemen, is the object we have in view; that is the design we had in going to a low figure, and we must trust to your forbearance to allow us to give the principle a full trial, so as to see whether we can, by reducing the

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cost of transmission, stimulate and increase the traffic and the business across the Atlantic. Gentlemen, we have been told that this has been adopted as a fighting tariff; it is no such thing. We do not want to force the other company, our competing company, into any arrangement with us; but we do want to establish such a traffic as will give us a fair return for our money, and not induce by high rates and large dividends other persons to invest their money in Atlantic cables. Gentlemen, we have arranged that after this half year no further addition shall be made to the renewal fund. Well, that will give us, at all events, some dividend, because we have been earning, even under the disadvantages we have had during the past half-year, what would be at least one per cent., and we hope to improve that because the traffic is increasing, and as it increases of course it will give us more. Gentlemen, under these circumstances I have to ask for your further forbearance and further trial of this plan and this principle so as to ascertain whether it is possible for us to fix the price of traffic across the Atlantic at a low rate and maintain thereby a moderate dividend, and offer no attraction for further competition. Gentlemen, I beg to move the adoption of the report.

The Marquis of TWEEDDALE seconded the motion.

Mr. WILLIAM ABBOTT: Last time I attended a meeting of the Anglo-American shareholders the attendance had a very unfortunate result, and therefore I will not dwell upon it now; but you may remember subsequent proceedings, because I had the audacity to oppose the election of a certain Director on this Board who shall be nameless. I came here to-day with certain theories in my mind, which I intend to expound, and perhaps the wisest course for me to have adopted would have been to wait till I heard other speakers, in order that the force of your remarks might have evaporated. You always have a persuasive way in urging the shareholders to adopt the policy which you recommend for the time. Now, I well remember, sir, that when we urged, as shareholders, that you should lower your rate, from I think it was 3s. a word, we were met by a distinct opposition on the part of the Board that it would be fatal to the interests of the Company. Now, it has proved that you were wrong in that respect. The only question I should like to put to you now—to the collective wisdom of the assembled shareholders—is, may you not be wrong now in going to the other extreme ["No."] A gentleman says "No." I do not know, but I fancy that the shareholders' patience, as you have alluded to it, is becoming somewhat exhausted, and therefore it is time to ask the question, "What are you driving at?" Do you expect by a reduction of the tariff to 6d. a word to coerce Messrs. Mackay and Bennett into adopting a policy of friendliness towards yourselves? Well, now, let us see what chance there is of that. Messrs. [illegible] Bennett, if I understand it, are not adventurers [illegible] have not come to England to find the [illegible]prise; they have found it themselves. The[illegible] a moral pledge with their proprietors that the[illegible]se the tariff beyond 1s. 8d. per word, and that if they [illegible] will return to each of the customers 6d. per word for every [illegible]ey have sent in the interval. Now, that is a very serious re[illegible]ibility for these gentlemen to take, and bear in mind that responsibility is accumulating every day, so that they are bound to keep the tariff at 1s. a word, while you desire to adopt a policy to force them, I suppose, into some arrangement Now, I must candidly say I have always supported the Board of this Company, but I think at a juncture like this we ought to see whether there is any common sense in the Company outside the Board. I should like to know from you, sir, what damage would accrue to us supposing you raise the rate to the same level as the Commercial Cable Company. Now, I want to be instructed upon that point, because bear in mind each of us has theories and ideas of his own. Every man thinks he is a good cable administrator, and that he would do so and so. I do not believe in that idea. I see here Sir Daniel Gooch, Sir James Anderson, Mr. Weaver, and others, men who have been connected with Atlantic telegraphy since its inception, and they must know more than I do or, perhaps, any of the shareholders. At the same time we want that point cleared up—what is there to prevent your advancing the rate to 1s. a word, and at least give us some signs of a dividend? We are in a specially advantageous position. We have four cables working with the Direct United States, and therefore it it a case of the best man wins; whoever does the business best will get the traffic. I shall be glad if you will inform us on that point. I see Mr. Smith, of York, here; he has always taken a very active part in connection with this Company, he has given himself an immense amount of trouble, his industry is wonderful; but if he had consulted me I should have told him at the beginning his labour was in vain. You never can go against a body of Directors with the slightest hope of success. They have the proxy power, they know exactly who are their supporters, and they have the power behind them of the Globe Telegraph, which is a large company, and therefore the question arises, how does this contest suit the Globe? I do not think it suits the Globe at all, but the vote of the Globe goes to support the policy of the 6d. per word. That is the point I want cleared up. I shall not detain you much longer, but there are two other points I should like to touch upon. The first is the secession of the French cable from ourselves. It seems the Anglo-American has always been unfortunate in its alliances. You remember we had a hard and fast and binding alliance with the Western Union Telegraph; by that we were to be safe for all time so far as American messages were concerned, and it came to us with equal surprise when we heard that Mr. Jay Gould had laid two cables for himself. Now comes the second secession, in the French cable, and I hope you will be successful in your legal process, and make these people refund some of the money which they have taken from us unlawfully. The only other point is whether it is not possible to reduce your capital account. If you notice in all the speculative prospectuses that are issued by enterprising cable makers they all call attention to the fact that this Company has four cables and a capital of £7,000,000. Well, now, the capital is only on paper. It is perfectly true that in the years of our prosperity a large amount of revenue (which otherwise might have gone to the shareholders) has gone to renewing our property, and we have duplicate cables which have been largely constructed out of revenue. They never say anything about that. Well, there is the fact—that £7 000,000 is an attraction to enterprising cable makers; and therefore why should you keep up the nominal value at £7,000,000, when the actual market value is not £3,000,000? If you were to show that the Anglo-American pays 3½ per cent, that it has four cables, and a million in sovereigns as a reserve, I think it would have a deterrent effect upon many of these speculative enterprises of which we have lately seen so much. You have alluded, sir, just now to the extraordinary fascination which men seem to have to put money into competing cables. Well, the last scheme was such an abortion I do not think you need really treat it as serious. I think, so far as you are concerned, you may regard yourselves as safe from competition for many years. Now, I see Sir James Anderson here, and I should like to draw him out, as he probably knows what an absurd scheme it was. It was a scheme to lay a cable from the Azores to the mainland, and, if I rightly remember, some years ago I spoke to Sir James Anderson on another scheme of the same kind, and he told me the current between the Azores and the mainland was so strong that in all probability, if they attempted to lay a cable, they would have to pay out sufficient to reach to the Gulf of Mexico (laughter). Sir James, perhaps that is fresh in your memory, or perhaps you used some strong language; but it has remained on my mind to the present day. I hope you will enlighten your shareholders as to where you are going as regards this competition of 6d. a word. I quite agree that the traffic is improving satisfactorily, and the public are getting the benefit. What I want to see is some return for the unfortunate gentlemen who have embarked so large an amount of capital in this Company.

Mr. SMITH (of York): My lord and gentlemen, at our last meeting you will remember I found myself in a position to support our Directors, because I thought they were acting for the benefit of the shareholders; at the present I cannot agree with them. There are several things in their report with which I find fault. There is no dividend—that they cannot help; but there is not even an expression of sympathy in the report from the Directors to the shareholders for their loss. With regard to the renewal fund, surely this large amount is worthy of a paragraph in your report. I have taken it out from time to time, and I see nothing about it. You will observe the colonial securities are less this half year than last by more than £53,000. Why is this—have they been sold?

[illegible]

[illegible] SMITH: This £72,000 or £75,000 uninvested—is the £53,000 that has been sold of colonial securities part of that amount? I want to know, because there is nothing in your statement here. If it is not invested, is it good business in these times, when we want every penny piece we can get together to go towards dividend? Other securities £26,000, you call them "other securities," what are they? Are they the uncollected debts? If so, why not state it. You have an amount of nearly £100,000 without any definite name for it. There is one thing that you should take into account, and that is, that you are dealing with nearly a million of money; you have got this last half year £50,000 more invested than the previous half year, and still you have less dividend upon that by £950. Now, it is rather a singular thing that you should have less dividends.

Mr. WEAVER: Less interest.

Mr. SMITH: Yes, dividend on the securities, whatever they are. Is this loss of interest for bank commission or from reinvestment of proceeds of sale of colonial securities, or what is it for? I should like to have some explanation. No doubt the Chairman will be able to give an explanation of these anomalies; but, in the future, it would be much better to have a paragraph in the report giving the details of this large sum of money. It would be much better for the shareholders and Directors, and it would not be a great deal of trouble to give. We have a right to know what has become of this money; it is our place to look after it. It is held up to the gaze of the world, and may be attacked by other people; I do not mean to lose sight of it myself. As to the future, there are some things in the report that are satisfactory and others that are not. There is a great and and continued increase of traffic; that is very satisfactory and encouraging, and will encourage us to go on with the 6d. tariff. I do not agree with Mr. Abbott; I think the 6d. tariff is telling the tale it ought to do. I have no doubt, with a little patience, we shall find it will succeed. You have only to take into consideration the low tariffs of other things which have succeeded. Take the land sixpenny telegrams, the penny postage, or the omnibuses, or anything you like. I think the 6d. tariff is the tariff of the day. I fancy, if we continue it, we shall find it a success. Moreover, it will prohibit, most likely, any other company from interfering with us for some time. We have against this to consider the continued competition, the action of the French company, and the Mackay-Bennett opposition. It is very serious opposition, but my opinion is that you will win the day in this struggle. I have not the least doubt, with patience, we shall win the day, and succeed in paying good dividends even with a 6d. tariff, but it wants patience and forbearance.

A SHAREHOLDER: When?

Mr. SMITH: I am not such a prophet as to tell you when, but the traffic increased by 152 per cent. in the last eight months. I believe, if you go on for twelve months at the same rate of increase, you will have a dividend again, and a very substantial dividend as well. I do not see why we should not. Business has been bad between this country and America; but with more business and traffic you are sure to get a dividend. To my mind it is evident a 6d. rate is increasing the traffic so rapidly that it must ultimately prove a success. I have considered this matter, and that is my candid opinion.

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If you will be patient and forbear I have no doubt you will have a very good dividend again. As shareholders we ought to be prepared to assist you with our patience and forbearance; but in the meantime you have a duty to perform as Directors. We, the shareholders, have been going without our dividends for four consecutive quarters, and I think it is time now you held out some hope that there will be a dividend—a fair dividend—on the 1st of May. It is not for me to tell you what, but I do hope you will see your way to pay a dividend by 1st May. There is another thing I would impress upon you, and that is that your business should be conducted with the strictest economy. There are some things where, I think, there might be some fairly good savings made, and you should give all the possible dividend you can. As far as I understand it, I see no reason why we should not have some dividend. Why not take £30,000 interest per annum of the renewal fund. Why not take that? It is over £30,000, it belongs to the shareholders—we have a right to it. I say, in this crisis, we have a right to have the £30,000 interest divided until after the crisis is passed; no doubt it will pass away, and then, when we can afford it, lay it by again. I have letters every morning from poor people begging and praying, with tears in their eyes, that I will bring this matter before you. I have had, since I have been in London, several letters from the provinces, and I think it is a suggestion you ought to bear in mind and act upon. If you take the £30,000, that will materially assist you in the present crisis. There is no earthly reason why you should not. You are masters of it. You see the Board of the Direct United States Company, like men, paid their shareholders the last dividend out of the renewal fund. They did not say they could not do it; they did it and the shareholders are all the better for it. In times like these Directors must do something out of the ordinary way to satisfy shareholders who have had no dividend, or they may find some fine morning a very disagreeable surprise. I contend that a renewal fund of nearly £1,000,000, is more than sufficient in itself for any contingency that can happen to this Company for many years to come.

Mr. Seeley: My lord, and gentlemen, I am very much surprised to hear from you the distinct avowal that this 6d. tariff had nothing whatever to do with the competition, or to force the other company to some reasonable proposition. I recollect perfectly well when you met us two meetings ago, you said you felt forced to reduce the tariff, in order to arouse them to come to some reasonable arrangement. If I am wrong you can correct me, but I believe those were your very words. Now, I think it is patent to the minds of anyone who thinks over this subject, that a 6d. tariff is not for the purpose stated by the Chairman. Even his lordship tells us it is a question whether the 6d. tariff will pay or not. Most of you, gentlemen, present here were present many years ago, when the tariff was reduced for the very purpose of forcing a certain company to come to a reasonable rate of working, and after trying it for some considerable time the Directors found it to be a failure. I think the tariff at the time was 1s., and our tariff prior to that was either 3s. or 4s.—that drop was, in proportion, almost as much as the present one. We were working at 2s. a word, and earning a very small dividend, not more than 3 per cent, and how is it possible that a 6d. tariff can pay you a dividend for years to come, because you have got to earn four times as much as ever you have earned before you can pay the same kind of dividend, namely, 3 per cent.? Therefore, without going into any more words, it must appear to you that it is preposterous to expect to be able to do so. I do not wish to take up your time, my lord, but I certainly must make these remarks, because I feel you have not fairly put the matter before the shareholders.

Mr. Wood: I rise to support the policy of the Directors in their 6d. rate to America. I think it is a very shrewd step, and I do not think anything else could have been done under the circumstances. In any case it would be fatal to change now and to increase the rate, at all events until it has been very thoroughly tested. Gentlemen have quoted a previous occasion on which a shilling rate was tried, but that was scarcely analogous with the present time. I believe that there is going to be, as everybody knows if you look round this country and America, an improvement of trade, and it will continue to improve. If so, depend upon it a 6d. rate will pay you well in time, and if you do not adopt it now you may depend upon it you will have to do it in the future, because it is quite in accord with the spirit of the times. In addition to that, by the adoption of a 6d. rate we are gaining the favour of the public which we lost before by our heavy charges, and rather set the public against us, and so encouraged competitive companies. The only other point worthy of our consideration is whether it would not be well to reduce the capital account for the reasons mentioned by a previous speaker. I think it would improve our property in the market very considerably.

Mr. Griffiths: I think we have exercised great patience. Allusion has been made to the Direct United States Company, and I have the greatest respect for the chairman of the company (Mr. Pender), and I think the Board of Directors of that company have acted wisely in distributing dividends out of their reserve fund. Now, that company happens to be one of those with whom in past times we were in deadly contest—war to the knife was recommended. "Bleed them to the death," as Bismarck says. We did so, and then came to a treaty. What were the results of the treaty? Why, the Direct United got much better terms than we did. Let us see the result of our warfare in times past. We constantly seize the opportunity of going to war and entering into treaties which are for the benefit of our enemies. I therefore think that as they have outwitted us during the struggle they will still more outwit us when peace comes. Not only the Direct United States, but, unfortunately, other companies are suffering from this. The Globe dividends are falling off, and we may anticipate the time will very shortly come when the shareholders of that important company will call on the Board to throw their vote into the other scale. One shareholder here thinks your policy shrewd. I regret that I cannot see the force of his arguments. The shareholders suffer, while the Directors are the only persons who profit. Gentlemen, this is a business Company, and we ought to be actuated not by principles of high policy, not by those principles which lead us to defend our country and act patriotically. We are but ordinary traders, we do but wish to make a profit on the money we have invested. What is the course of business we have undertaken? We have already more than sufficient cables to carry all the business developed, and yet we are accumulating enormous reserve funds by way of insurance. By all means insure all that is necessary, but that reserve fund is sufficiently large to buy two new cables. We have now four cables of our own, which are more than sufficient for the work, and there are the cables of the Direct United States, the French cables, and the cables of the Mackay-Bennett, which I am afraid at some future time will come into the pool and water our capital still more. What is the effect of the warlike policy? That our opponents still maintain their rates, and while 6d. is not sufficient to earn a dividend on so large and so watered a capital, 1s. on a much smaller capital intact, and never watered, is likely to produce a very large return indeed. Gentlemen, I think the Directors should express in their report some sympathy with their shareholders; patience may be good, but sympathy is better. Mr. Smith alluded to something which he was afraid to utter. He will allow me to interpret his thoughts. I know what he means. It is this—that a motion should be proposed that the Directors should exhibit their sympathy by reducing their fees. Gentlemen, I need say no more. We are in an unfortunate situation; let the Directors show that they appreciate the situation. Let them give up a portion of their fees, and then we will mutually vote for their report; if they do not do so, they must expect that the attitude of dissatisfaction that is now felt will increase so as to bring new Directors forward. I shall be happy to propose my friend Mr. Smith and others who will stick to the shareholders, and are willing and able to work for them.

Mr. Newton: I did not intend to say anything to-day, and should not have done so excepting for the remarks of Mr. Smith in reference to the accounts. At the Direct Cable meeting I spoke of the unfortunate position of the Anglo-American in not being able to support you in the fight you are now engaged in. This Company is in absolute weakness in the struggle in which you are engaged from your Articles of Association locking up your reserve fund from you in times of emergency. I say this meeting should not part without some resolution being passed by a large majority to alter the renewal fund into a [illegible] fund for the shareholders. Messrs. Mackay and Bennett know [illegible] we'l that they have you on the hop, and the reason why I sold my stock in this Company is because you are not in a position to fight them. They know that you will have to capitulate, because you cannot use your reserves to keep you in bread and butter. Many poor shareholders have invested their money in this Company, and many brokers told their clients they could safely invest in Anglo-American Deferred, and they were almost sure of a dividend; but your Articles of Association actually rob you of the dividend. It is money that has been reserved for the purposes of the Company, and it is not now available to interest the revenue. You may close your eyes to the fact if you like, but [illegible] to [illegible]ing is a question of rates, and if you go on with 6d. you will not develop [illegible] paying trade. At least, that is my opinion, gathered from men of experience, and gentlemen on the other side of the table. If the war goes on, and you do not make your renewal fund available for some sort of dividend the shareholders will certainly reduce your fees, as certain as you are sitting there. It is impossible for the shareholders of telegraph companies to pay gentlemen over £30,000 a year for directing these properties. We know perfectly well it is £33,000 a year ["No"]. I know my figures; £33,000 a year is paid to directors of telegraph companies, £2,500 in this company, £3,000 in the Direct, so many thousands in the Eastern, and so many thousands in the Eastern Extension. You cannot close your eyes, my lord, to the fact. We do look upon it in that light; we pay you handsomely to protect our property, and you are bound to think of the poor shareholders who have not too much money. Many have gone into telegraph properties because it was an essential requisite, and they look for a return. I do wish that you could make one. I know the almost impossibility, but I do think that "where there is a will there is a way," and you can find some way to remove this incubus of £7,000,000 of capital which does not exist. There is £4,000,000 of capital which does not exist, according to the representation of the Stock Exchange value, and probably £3,000,000 ought to be written off if you can find some way of doing it. I know the difficulty, I know it is almost impossible, but still I think that the shareholders have suffered so much from conflicting schemes being brought forward owing to this large capital that if you direct your minds to it, your shareholders will meet you more than half way to remove this blot from your balance-sheet.

Mr. Jackson said that he did not wish to occupy much of their time on this melancholy occasion. After 21 years their stock of £7,000,000 was valued in the market at £1,000,000. He thought, however, that they were right in adopting the 6d. tariff and trying to develop the traffic. He opposed the reduction of the capital, and said that their capital had nothing to do with the competition. He advocated the taking of deferred messages and the insurance of cables.

Mr. Barron thought that the Directors had had a most unpleasant duty to perform, and that the shareholders should show sympathy with them. He defended the adoption of the 6d. tariff and expressed the belief that the Company had a great future before it.

The Chairman: Gentlemen, it now becomes my duty to say a few words in reply to the observations that have been made by the several shareholders. I am glad to have received such support from my friends Mr. Smith, Mr. Jackson, and the gentleman who has just spoken. I assure them that it is a great encouragement to the Directors to do all they can for the shareholders when their motives

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and actions are treated with such forbearance and generosity. I am very glad to find my friend Mr. Jackson, notwithstanding his objections to the renewal fund as a stumbling block, still finds its existence a great backbone to the company. If I might be allowed to take the liberty of saying so, I have always stood firm for that backbone, and therefore I hope Mr. Jackson, when he criticises the action of the Board in the future, will remember sometime ago if we had taken his advice that backbone might not have existed all, or existed only in a very qualified form. Mr. Abbott began by saying that I had called this a fighting tariff; if I recollect rightly what I said was the very reverse. I said it was not a fighting tariff, but one adopted with a view to test how far a low payment for sending messages across the Atlantic would develop the traffic and become a paying tariff to us. That is the sole object of the Directors in the policy they have adopted. Mr. Smith, Mr. Jackson, and the gentleman who has just sat down, have supported that view with such strong and such weighty reasons, that it is really unnecessary to add a word. I only hope that Mr. Jackson and Mr. Barron may live to see the prosperous result of that tariff. Mr. Abbott talks about reducing the capital. I do not think, from the reception that proposition has received in the room, that it is one that is very acceptable to the shareholders. I really, for my part, cannot see what the practical use of it would be. Supposing you reduce from £7,000,000 to £3,500,000, the result would be that when you paid a dividend of two or three per cent. it would appear in the public prints as dividends of five or six, and that would have exactly the effect that we want to avoid. Gentlemen, I think the true policy is to leave the capital where it is. People who understand the thing know exactly what three per cent. on the capital is, whether it is watered or not, but those who would be attracted by a large dividend would not know how that dividend was made to be apparently so large when it really meant 2 or 3 per cent. on £7,000,000. Mr. Smith spoke of some changes in the investments. I quite agree with him. I think in future a more detailed account of the investments and the way they have been dealt with may be given. The fact is there were some colonial securities which under the circumstances we were advised we had better not hold. We sold them at a trifling loss, and that is the reason for the apparent difference in the amount this half year and last. Well, Mr. Smith also suggested that the interest of the renewal fund should in future be applied to dividends. Well, we have no hard and fast line on the point, and all I can say is your directors will consider carefully before the month of May what should be done in that respect (applause). I hope I may not be understood as pledging the Directors to take that line, but we will consider it most carefully, and give you our decision according to what we think best in the interests of the shareholders. Well, Mr. Griffiths spoke of the Direct Company paying a dividend out of the reserve fund; Mr. Griffiths is a lawyer, and knows just as well as I do that what is legal for the Direct Company would be illegal for us. The Direct Company's fund is not a renewal fund it is a reserve fund, and anyone who is conversant with these matters knows the difference. The renewal fund is meant solely for the reproduction of the plant, and a reserve fund is meant to serve any purposes which the Directors may choose to put it to. We could not legally do what the Direct Company have done. Mr. Jackson has suggested that we should take deferred messages, but there again we are met by the law. I believe that the Telegraph Act prescribes that messages shall be sent in the order in which they are brought to the office, and if we attempted anything of the kind suggested we should have the Post Office on our backs prosecuting us for an infraction of the law. With regard to the insurance of cables, I confess that is a new idea to me; but, at first blush of the subject, I should say that cables are not sufficiently numerous, and they are too valuable to admit of insurance. The fact is the premium you would have to pay upon them would be so large that it would not be worth your while. Gentlemen, I think those are the only observations I need trouble you with, and I will now put the resolution.

The resolution was carried unanimously.

The retiring Directors and Auditors were re-elected, and a vote of thanks to the Chairman and Directors then terminated the proceedings.

The India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

Report of the Directors for the year ending December 31st last, to be presented at the twenty-third ordinary general meeting of the shareholders, to be held at the Cannon-street Hotel, E.C., on Tuesday, 22nd inst., at 12 o'clock :—

The accounts show the net profit for the past year to be £59,408. 5s. 2d. Adding £40,947. 8s. 3d. brought forward, and deducting £20,800 interim dividend paid in July, there remains a disposable balance of £79,555. 13s. 5d. The Directors recommend the distribution of a dividend of £1 per share, free of income-tax, amounting to £41,600, making, with the interim dividend, a total payment for the year of 15 per cent., and leaving £37,955. 13s. 5d. to be carried forward. The business done has been up to the average, notwithstanding the general depression, and the keen and increasing competition in our special trades. The Company's six per cent. mortgage debentures for £100,000 having matured in March, were paid off, and have been replaced by four-and-a-half per cent debentures for £200,000, having ten years to run. This increase has enabled the Company to reduce its general liabilities by an equivalent amount, and to work financially with greater convenience. The laying of the West African Telegraph Company's cables has been completed to the entire satisfaction of its Directors and engineers. The West African and African Direct systems of cables now include over 3,500 miles manufactured and laid by this Company, and the Directors feel satisfaction in reporting that the whole operations were carried out with complete success. The cables were laid on a difficult and unhealthy coast, under the able management of Mr. Matthew Hamilton Gray, to whom as well as to the whole staff employed the thanks of the Company are due. A small steamer—the "Buccaneer"—was purchased for use in the near-shore work of the expedition, and was found most useful. The Silvertown works have now been completely fitted up by our own staff with the electric light. There are 140 arc lights and 1,300 incandescent lamps, forming one of the largest installations in the world. The result is a great saving in cost and a great increase of light, while the health and comfort of the workpeople and the facilities of working are much improved. The Company's works, machinery, and vessels are all in first-rate order. Mr. Scott, the director retiring by rotation, offers himself for re-election.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 4th February amounted to £3,438.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of January amounted to £20,400, for the corresponding month in 1886 to £19,880, and for the corresponding month in 1885 to £20,800.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—The directors of this company propose paying (subject to the audit of accounts) a dividend of 15 per cent. (£1. 16s. per share), in addition to the 5 per cent. already paid, making 20 per cent. for the year 1886.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ended 31st January were £5,875.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts for the week ended 4th February were £2,828, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Feb. 9.		Business Done Week Ending Feb. 9. Highest.	Lowest.
Anglo-American	32,	33	32	31⅝
Do. Preferred	52,	53	52¾	51⅝
Do. Deferred	11,	12	12	11
Brazilian Submarine	10½,	10¾	10¾	10⅝
Cuba	11½,	11¾	11 11-16	11½
Do. Preference	18,	19	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	7¾,	8	7⅞	7⅝
Eastern Telegraph	10½,	10⅝	10⅝	10½
Do. 6 per Cent. Preference	13,	14	13½	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	10½,	10¾	10¾	10 9-16
German Union	8¾,	9¼	—	—
Globe Telegraph and Trust	4⅝,	4⅞	4⅞	4¾ xd.
Do. Preference	11⅝,	11⅞	11⅞	11⅝ xd.
Great Northern	13⅜,	13⅝	13½	—
Indo-European	34,	35	34¾	—
Reuter's	6¾,	7¼	—	—
Submarine	190,	200	—	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	8½,	9	8⅝	—
Western Brazilian	7½,	8	7¾	7½
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Companies.	Closing Prices. Feb. 9.		Highest.	Lowest.
Consolid. Telephone and Maintenance	¾,	⅞	¾	—
Oriental	3-16,	5-16	—	—
United Telephone	12¼,	12¾	12⅝	12 5-16

ELECTRIC LIGHT.

Companies.	Closing Prices. Feb. 9.		Highest.	Lowest.
Anglo-American Brush Light (£3 paid)	2,	2½	—	—
Do. (fully paid)	3¾,	4¼	—	—
Swan	1⅝,	1⅞	—	—
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Companies.	Closing Prices. Feb. 9.		Highest.	Lowest.
Telegraph Construction	38,	39	39½	38
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23¾	23½

TRAFFIC RECEIPTS FOR JANUARY, 1887.

Companies.	Jan., 1887.	Jan., 1886.	Increase.	Decrease.
Cuba Submarine	3,200	2,891	309	—
Direct Spanish Telegraph	1,888	1,700	188	—
Eastern Telegraph	53,435	57,317	—	3,882
Eastern Extension	39,331	39,699	—	368
Great Northern	20,400	19,880	520	—
West Coast of America	5,875	—	—	—

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NOTES.

EXETER.—The theatre at Exeter is to receive an installation of arc lights.

EDISON'S ILLNESS.—Mr. Edison is now reported to have fully recovered from his recent severe illness.

PLYMOUTH.—Steps are being taken for the formation of a local electric lighting company in this town.

EXMOUTH.—Courtlands House, near Exmouth, the residence of Mr. W. Lethbridge, has been supplied with a plant of about 100 lights by Messrs. Crompton and Co.

HOUSE LIGHTING.—Messrs. Verity and Son, of Covent Garden, have recently supplied electric lighting plant for the town residence of Lord Chesterfield, and also for his country seat at Rangemoor.

NEWTON-ABBOTT.—The Western Counties and South Wales Telephone Company is about to open an exchange at Newton-Abbott, a town in Devonshire, and intends also to run trunk wires from this centre to several neighbouring towns.

THE ANGLO-AMERICAN BRUSH COMPANY.—We would call the attention of our readers to the annual report of the Anglo-American Brush Company, which appears in another column, a good deal of which will be found to be of an interesting character.

ELECTRICAL ENGINEERING AT THE EDINBURGH UNIVERSITY.—At the Edinburgh University, Mr. A. C. Elliott, B.Sc., has been appointed Chief Demonstrator in Electricity for the class in electrical engineering which has recently been opened by Prof. Armstrong.

THE VALUE OF THE AUTOMATIC FIRE ALARM.—During the recent fire at the Hotel Continental, Berlin, the whole of the servants and guests were aroused at 6 a.m. by the automatic fire alarms with which the building is provided, and were enabled to make their escape.

THE TENDERS FOR LIGHTING THE NEWCASTLE EXHIBITION.—It is announced that for the electric lighting of the North Gardens and the West Court, the tenders of Messrs. Woodhouse and Rawson, and of Messrs. Clark, Chapman and Parsons, of Gateshead, have been accepted.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The next meeting of this society will be held at the Institute of Civil Engineers, on Thursday, February 24th, at 8 p.m., when the discussion upon Prof. S. P. Thompson's paper on "Telephonic Investigations" will be resumed.

THE BATTERSEA FIRE.—It appears that on the occasion of the recent disastrous fire at Battersea the local fire station found themselves cut off from telegraphic or telephonic communication, owing to the breaking of a wire, and in consequence much valuable time was lost. Another account says that the delay was due to the telegraph wires not having been yet repaired.

TELEPHONIC COMMUNICATION IN THE NORTH.—Communication has been opened by the National Telephone Company between Glasgow and Stirling. This is the first link in the extension of the system at present being carried through the North of Scotland. It is expected that the line to Dundee will shortly be completed, and ultimately the service will be extended as far as Aberdeen.

THE ANGLO-AMERICAN BRUSH COMPANY.—We understand that the central lighting installation at Temesvar, Hungary, about which we recently gave some interesting details, has now passed into the hands of the Anglo-American Brush Electric Lighting Corporation. This company has also taken over the business of Messrs. Kremenetzky and Mayer, of Vienna, manufacturers of electric lighting plant.

THE FRENCH TELEGRAPHS.—M. Granet, the French Minister of Posts and Telegraphs, is introducing several minor reforms into the Telegraph Department, in which he is in part following the lead of the English Post Office. A system of prepayment of telegrams by stamps is to be established, messengers are to wait five minutes for an answer, and a scheme for "express" messages is being worked out.

ARC LIGHTING.—The Royal Comedy Theatre has been supplied with a small arc light installation, which is used for lighting the outside of the building. The plant consists of a 1½ unit Goolden and Trotter dynamo, supplying four 1,000 candle-power arcs, and driven by a 2 horse-power Marshall vertical engine and boiler. The work was carried out by Messrs. E. L. Berry and Co.

BITUMEN CONDUITS.—"Mr. Nicoll thus commenced,"—we quote from the opening words of a pamphlet, entitled "Underground Telephone and Telegraph Communication," by Mr. Donald Nicoll, A.I.C.E., Member of Council Inventors' Institute, &c., &c., &c. From this we learn that on the 29th ult. Mr. Nicoll read, at the Café Royal, Regent-street, a paper upon the use of bitumen for the construction of wire conduits "before several Experts eminent in Telegraphic and Telephonic Science." In spite of the solemnities with which the subject is introduced, we have read Mr. Nicoll's paper with considerable interest, and we very largely share in his belief in the value of bitumen for the purpose indicated.

A SERIOUS STRIKE.—A few weeks ago the telephone service of Lancaster, U.S., was temporarily deranged, owing to the strike of the female operators of the central exchange. The difficulty arose from the fact that the company had the lower window panes painted, which prevented the young ladies from seeing what was going on in the outer world, and on this the sashes were reversed so that the painted panes came to the top and the clear panes at the bottom. The managers then had the lower sash screwed down. The young ladies could not stand this infringement on their rights, and consequently struck. The strike has now terminated, but we deeply regret to state that we have been unable to ascertain upon what terms the settlement was effected.

TOWER LIGHTING IN THE STATES.—The system of street lighting by placing arc lamps upon very tall masts, which go by the name of "towers" in the States, still continues to meet with favour, and many of the arc lighting companies are bringing out "towers" of their own design. It is stated that whereas on an average one arc lamp placed at the usual level displaces only six gas lamps, the average for tower lights amounts to no less than sixteen gas lamps displaced. It appears to us, however, that by a proper system of lenses—such, for instance, as that devised by Mr. Trotter—equally good, if not better, results should be attained. However admirable from an æsthetic point of view the effect of these high lights may be, the masts themselves seem generally to be the reverse of objects of beauty.

THE MAY ISLAND ELECTRIC LIGHT.—The master of the Swedish steamer "Frithiof" reports that early on Friday morning, with the very dense fog then prevailing, they had got within three miles of the May Island before the very powerful electric light recently placed in the lighthouse could be noticed, and it only resembled a dim light from a single candle. On the previous voyage this same steamer, with clear

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weather, sighted the May Island light at a distance of forty-six miles, "thus showing," says the *Scotsman*, "what little effect the electric light has of showing through fog." It seems to us, however, that a light which is visible through a dense fog at a distance of three miles, even if reduced to the effect of "a single candle," is by no means open to the charge of being of little effect.

Electric Light Inspectorship in the United States. An examination was recently held at Washington for an appointment as electric light inspector to the Treasury Department. We do not know precisely what the duties and emoluments of this office may happen to be, but as the examination is not of a very abtruse character it is just possible that some of our readers might like to enter for any succeeding vacancy. We will therefore quote a few of the questions as samples of the paper :—"State Ohm's law, and give the equation which expresses the relation of electrical units involved." [The candidate is not required to solve the "equation."] "What is an ampere meter? What is a volt meter; and how does it differ from an ampere meter?" "What is the law governing the distribution of currents in multiple arc branches of an electrical circuit?"

The Sale at the Indian and Colonial Exhibition.—On this subject we have received the following note from Messrs. Davey, Paxman and Co., of Colchester. We are very pleased to have this correction, although in justice to ourselves it may be mentioned that our information was derived from a source which might reasonably have been supposed to be of an absolutely authentic character. Messrs. Davey, Paxman and Co. write :—"Referring to the note in your issue of the 4th relative to the sale at the Colonial and Indian Exhibition, we must ask you to kindly correct the statement you make that one of our engines, indicating 300 horse-power, realised only £320. As a matter of fact this engine sold for £475, while all our smaller engines realised new prices. We trust you will kindly put this matter right, more especially as we hear that some interested parties are asserting that we got no legitimate bids, but bought all our engines in. We assure you we have no reason to complain of the results of the sale."

The New York Wire Conduit.—We are sorry to learn that the Dorsett system of conduit, which, after long consideration, was finally adopted by the New York Electric Subway Commissioners, has not in all respects fulfilled the expectations which were formed of it. It will be remembered that the object aimed at was to obtain a conduit which should be gas and water tight, and in which wires might safely be placed without any protection beyond gutta percha or india rubber insulation. It seems, however, that the portion laid under the Sixth Avenue is already leaking, and (according to our authority) "it is impossible to keep it water tight." In the long run we are inclined to think that the Boston plan will be found to be the most successful. That is, to employ insulated wires coated with lead, or, as they have found to answer best in Boston, with an alloy made of lead and a very small quantity of tin, and then to rely on the conduit merely for mechanical protection. However the construction of the Dorsett conduit is being pushed forward vigorously in New York.

Blackpool.—Messrs. Johnson and Phillips have written as follows to the *Blackpool and Fleetwood Gazette* :—"In the report of the monthly meeting of the Blackpool Town Council, we observe a remark of Mr. Alderman Hall that the 'Brockie-Pell lamp is not so good as described, or it would have been more generally adopted.' In justice to the patentees and ourselves we cannot pass over this unnoticed, and shall be thankful if you will kindly find room in your next issue for the following remarks :—1st. That the patent was only taken out about a year ago, and we have every reason to be satisfied with the number of lamps sold since that time, the users including several Governments besides our own; the Leeds Corporation; railway, dock, and telegraph companies; and private firms too numerous to mention. 2nd. That in no case has it been unsuccessful in competition for Government and other contracts. 3rd. That no other arc lamp has given such excellent results in every respect as this, and in our opinion it is merely a question of time when it will be generally adopted wherever the arc lamp is suitable."

The National Electric Light Association of the United States.—This important body is now holding its first session for the present year at Philadelphia, the delegates having assembled on the 15th inst. The programme sets forth that especial attention will be paid to the question of the best methods of station construction and equipment. The following is the wording of the circular issued by Mr. A. J. De Camp, the chairman of the executive committee :—"As many new stations will probably be built during the coming year, and those already built will be extended or remodelled, it is proposed to invite plans for exhibit at the meeting in February; this, in connection with the engines, boilers, dynamos, for arc and incandescent lighting, for motors, and their relation to each other, are subjects which will be discussed at the next meeting. In view of the many schemes which are brought to the attention of the investors, all of which require capital, the majority of which are visionary, but none of which can safely be ignored without investigation, it is manifestly to the interests of every one so engaged to be connected with an association so eminently qualified to discuss such matters, from both a practical and theoretical standpoint."

Cockermouth.—The Local Board of Cockermouth, which, as we recently mentioned, are promoting a Bill for powers to establish a central lighting station in that town, have requested Mr. W. H. Massey to furnish a report upon the case. Mr. Massey has visited the town, and has formed a favourable opinion as to the employment of the water-power available. At a meeting of the Board, according to a local journal, "Mr. Massey spoke very favourably of the advantages of the electric light where a great number of lights are required in a small area. He said that in such a case electric light might be cheaper than gas, and very much healthier; and for mansions, or places where expensive pictures or works of art and costly textile fabrics are kept, the electric light is infinitely superior to gas; but for streets or places where few lights are required the electric light could not be produced as cheaply as gas. Mr. Massey, in his report, which is to be appended to the Cockermouth Local Board Bill now before the House of Lords, will speak highly of the water supply of the town as being well adapted for securing motive power at a cheap rate. The wish of the Local Board is to acquire the power to adopt electric lighting at any time when the inhabitants may require it, and for the purpose of preventing any electric lighting company starting operations in the town."

Telegraph Clerks.—On Tuesday evening a meeting of second-class telegraph clerks was held at Foresters' Hall. A resolution was passed thanking the Postmaster-General for his consideration of their petition, but expressing disappointment at the unsatisfactory reply, in which it was stated that the staff at the central station had received material benefits by the expansion of the classes. A resolution was passed deciding to call attention to the fact that the advantages were nullified by the enormous influx of provincial clerks, whereby the

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London men lost their seniority and chances of promotion.—A meeting has also been held of the telegraph clerks employed in the Dundee Post Office to consider their position with regard to the Royal Commission on Civil Establishments. Letters were read detailing the course which is being pursued at other centres, and in the course of a discussion which followed, the speakers claimed that the telegraphs should be put on an equality with other branches of the Civil Service. The refusal of the Postmaster-General to furnish the statistical information essential in stating their case to the Commission was strongly condemned, and the withholding of this information, it was declared, would tell severely against their claims. A vote of confidence in the Liverpool Central Committee was passed unanimously.

THE CHURCHWARDEN'S HAT.—A case that came before the Clerkenwell County Court a few days since possesses features of more than ordinary interest. The plaintiff was churchwarden of the parish of Clerkenwell, and claimed from the defendants, the United Telephone Company, the sum of £1. 1s., being the cost of a new hat irreparably damaged by the fall of a telephone wire. This distressing incident occurred near King's Cross railway station. This plaintiff was talking to a brother-vestryman, when the telephone-wire, without warning, fell upon him and, according to his evidence, "entirely smashed his hat." The company admitted their liability by paying 10s. 6d. into court; but this the plaintiff's solicitor "considered an insult to a churchwarden." It is hardly credible that the Telephone—or, indeed, any other—Company could seriously imagine that a churchwarden would wear a hat worth only 10s. 6d.; and the defendants' solicitor excused, as far as it was possible, the apparent insult by explaining that "his clients had only been sued for damage to a hat." A verdict was given for the plaintiff, with costs, and the company may esteem itself fortunate that they got off so cheaply. Had their wire cut off a churchwarden's head instead of merely injuring his hat, they would have found themselves in an awkward position.—*St. James's Gazette.*

THE LATE SIR JOHN BATEMAN-CHAMPAIN.—A correspondent writes to *The Times* as follows:—"On the 2nd inst. *The Times* published an obituary notice of the late Colonel Sir John Bateman-Champain, R.E., K.C.M.G., in which some reference occurred to the remarkable impression which that lamented officer's character had made on the people and statesmen of Persia and on the Shah himself, an impression originally made during his work in the country many years ago, and maintained by his occasional visits of inspection since. The depth of that impression comes out forcibly in a circumstance which has occurred since Sir John Bateman-Champain's death. The following telegram, sent by order of the Shah himself, will in a measure speak for itself; but by those who know how unusual a step this is for His Majesty to take, and how special in significance is this departure from the rigid etiquette of the Court of Teheran, this testimony to Colonel Champain's qualities will be appreciated as of a very exceptional and striking character. And the expression of such a feeling regarding a British officer who had been so long and intimately associated with Persia is, in its public bearing, by no means to be undervalued. To all but the very few Englishmen who already knew something of the Shah's personal character, this example of His Majesty's appreciation of noble qualities and the touching delicacy with which he expresses his feelings of sincere sympathy with the bereaved, will come almost as a revelation:—'Téhéran, 10 Février, A la famille Champain.—Par ordre de Sa Majesté Impériale mon auguste maître, je viens vous exprimer ses vifs regrets en apprenant la perte douloureuse que vous avez faite dans la personne estimée de Monsieur Champain, qui a laissé tant de souvenirs ineffaçables en Perse.—Le Ministre des Affaires Etrangères, YAHIA.'"

THE DIRECT CONVERSION OF HEAT INTO ELECTRICAL ENERGY.—H. E. Hinghausen and H. Nerust have recently described in *Wiedemann's Annalen* a phenomenon of very considerable interest, one which, in fact, amounts to a new method of obtaining an electric current by the direct conversion of heat. In some respects this new discovery resembles the effect which was first observed by Hall a few years since. For the benefit of students we may first explain that Hall's experiment was the following:—If a narrow slip of gold leaf be traversed by a current from end to end, and if a delicate galvanometer be connected to two opposite points on either side of the slip, it is obvious that these points being at the same potential no current will traverse the galvanometer. But if a magnetic field be now established so that the lines of force pass through the gold leaf in a direction perpendicular to the plane of the latter, then it is found that the points diametrically opposite upon the sides of the slip are no longer at equal potential, and the galvanometer is now traversed by a current whose value proves to be different for different metals. Various suggestions have been made as to the cause of this remarkable result, but no explanation seems as yet to have been definitely agreed upon. This being understood, the discovery now made in Vienna can be explained in very few words. If the current of electricity which traverses the slip longitudinally be removed altogether, it may be replaced by a *thermal* current, and we shall still get an electric current in the galvanometer. That is to say, if a thin slip of metal placed, as described, in a magnetic field have its two ends maintained at different temperatures, then a difference of potential is set up between the two opposite sides of the metal slip. The experimenters state that they have satisfied themselves that the current so produced is not due to any thermo-electric action between the contacts. The fact that the direction of the current is reversed when the direction of the magnetic field is reversed is in itself sufficient to remove this objection. The effect is naturally very minute; with a square plate of bismuth, measuring 5 centimetres on each side, and 2 millimetres thick, a field of force represented by 5,000 C.-G.-S. units, and a difference of temperature caused by placing a plate of mica against two sides of the bismuth, one dipping in cold water and the other heated by a gas flame, a difference of potential amounting to 0·00125 volts was observed. With iron instead of bismuth the current is in the reverse direction.

THE PHŒNIX FIRE OFFICE RULES.—The ninth edition of the Phœnix Fire Office Rules has just been issued, and is prefaced with the following note:—"The estimation in which these rules are held is well known; not only has nearly every important installation in this country been placed up in accordance with them, or since altered so as to conform to them, but the rules are used in our colonies, and have been translated into various foreign languages. The demand for copies has been so great—from abroad as well as at home—that the eighth edition has completely run out, although such a short space of time has intervened since its issue." The following are the principal paragraphs which have undergone revisal since the last edition:—"All conductors of a larger sectional area than No. 14 S. W. G. should be composed of strands." "When the 'multiple parallel' system is intended to be used in any building special permission must first be

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obtained. The insulation of the conductors should be of the highest possible character, similar to that described in Rule No. 20, for the primary conductors when secondary generators are used; and all work should be of the very best possible description, and on the surface where practicable. Every parallel must have an efficient automatic 'protector' of such make and design that if the difference of potential of that parallel should rise to 25 per cent. above the normal from any cause whatsoever, then the protector will instantly bring back the potential to the normal, or else cut out the parallel. Means must also be adopted in the dynamo room for maintaining the constancy of the current whatever number of lamps may be burning. A main switch must be placed in a fireproof box in a secure and accessible position outside the buildings when the electricity is generated externally; when the source is internal then it must be situated in the dynamo room. To be approved by the inspector from the fire office. By 'dynamo room' is meant any place in which the electricity is generated." "Wherever electricity is supplied from a 'central station' to one or more buildings, accurate insulation tests should be made at least once daily over the whole system, including every building on the circuit or circuits, and a record be kept of the same. Too much attention cannot be bestowed to this matter, especially where secondary generators are employed, or multiple parallel used." "An electrical power installation requires the same safeguards that apply to an electric light installation, in which the conditions of supply and the electromotive force of the current are similar."

Electric Lighting in Vienna.—According to the *Neue Freie Presse* it would appear that Vienna is likely still to remain in the dark, so far as electric lighting is concerned, in spite of the anxiety of the inhabitants to avail themselves of its advantages. The municipal council has made such extreme use of its proprietary rights in the streets, and has imposed such onerous conditions on the permission to lay down cables under them, that the burgomaster has been informed by the representatives of two contractors for central lighting stations that it would be impossible for any contractor to undertake the work under the conditions imposed. The gas company, which had undertaken the electric lighting of the two court theatres, and had already made considerable progress with the preliminary works, have been obliged to inform the management that they cannot carry out the contract under the conditions imposed by the municipality. The following are the most important of the conditions which are objected to by the contractors:—I. The Municipality reserves to itself the right of demanding that within three months from the time of notice being given, all temporary constructions shall be removed and the streets be restored to their normal condition under the penalty of confiscation without compensation. II. The Municipality shall have the right of ordering the cables to be shifted to new positions for any reasons whatever, and as often as it pleases. III. The Municipality shall be at liberty, as often as it pleases, to order any defects existing according to the opinion of the Council, or that of any expert chosen by them, to be remedied within a time to be fixed by the Council under penalty of confiscation. IV. The Municipality decrees that in case of any damage being done to the streets, or to any public or private property where the works are being carried on, the contractors shall be responsible for it, and the only appeal from the magistrate's decision shall be to the parish authority. This condition is actually illegal, and could not possibly be submitted to in the present state of things. V. Finally the Municipality demands a yearly rent of about £370 for the permission to lay the cable for the new Imperial Theatre, and about £400 for the cable for the lighting of the Comb Opera House. In the case of the opera house this rental is at the rate of nearly £2,500 for a mile of cable, while the tramway company only pays an annual rent of about £137 a mile. The contractors will use every means open to them at law to endeavour to have these resolutions rescinded. In the meantime electric lighting in Vienna is at a standstill, and the journal animadverts strongly on the systematic attempts to stifle an enterprise which ought to be strongly and universally supported. Our own Electric Lighting Act is usually thought to be by no means what it ought to be; but, in comparison with the Viennese regulations, it would appear that we have very little to complain of.

Transmission of Power in Spain.—We recently referred to a project which had been set on foot in Spain for the electrical transmission of power from the River Tunia to the town of Valence, and its distribution for general purposes. A company, calling itself "La Sociedad Electro-Dinamica Cossi, Mari y Ca.," has been established for this purpose, and has issued a circular containing some further information as to the details of the project. We may premise, that so far as appears, the company has not yet selected any particular type of dynamo or motor. The turbines and dynamos are to be laid down at a place called Chulillas, at a distance of 37 miles from Valence. At this point the river is about 120 yards in width; a dam, 3ft. above the ordinary level of the water, will be constructed across the bed of the stream, and the water will be brought to the turbines through a canal nearly two miles in length, considerably more than one-half of the distance being through a tunnel. It is clear, therefore, that this will be a costly undertaking. The head of water and the flow attainable does not appear to be stated, but it is calculated that 2,933 effective horse-power will be obtainable. The conversion into electrical energy is estimated to entail a loss of 27·75 per cent., leaving 2,119 E.H.-P. available at the terminal of the dynamo; 10 per cent. is then allowed for the loss in the line and 23·5 per cent. in the motors. It is thus expected finally to obtain 1,459 H.-P. for use at Valence. The cost of working for the entire installation is expected to amount to £4. 3s. per day, and the selling value of 1,459 H.-P. is reckoned at £16. 10s. per day, leaving a daily profit of £12. 7s., or, say, a clear revenue of £3,750 per annum. We shall be sincerely glad to learn that these expectations are realised in practice. There is, however, one point that will probably strike most of our readers in looking over these figures—namely, that while the remaining part of the calculation appears to have been carried out with great care (even to the second place of decimals), yet the item of electrical loss in transmission has been set down, one is almost inclined to think in a casual sort of way, at 10 per cent. The authors of the scheme are, of course, perfectly entitled to fix upon any arbitrary figure for the loss in transmission which they may happen to prefer, provided always that they also make allowance for sufficient expenditure in copper. According to the above figures, we have in this case about 2,200,000 watts at the terminals of the dynamo. Suppose that we allow 10,000 volts for the E.M.F.—decidedly a high figure (especially when the question of *distribution* at Valence is taken into consideration). We shall then have a current of 220 amperes which is to be transmitted over a circuit about 70 miles in length. The loss in the mains being limited to 10 per cent., or 220,000 watts in all, it will be found that the total resistance of the line must not exceed 4·55 ohms, or 0·065 ohm per mile. This represents a conductor weighing about 5·65 tons per mile, or a total weight of 395 tons of copper for the complete circuit—a figure which probably represents an expenditure of not less than £40,000 for the line alone.

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INCANDESCENT LAMP MANUFACTURE.—VIII.

BY J. SWINBURNE.

Carbonising.

Carbonising is simply raising the prepared material to a high temperature out of contact with the air. The prepared threads or blanks are placed in a closed vessel in a suitable furnace, and raised to a red or a white heat. The kind of furnace used depends on the temperature desired. The action of heat on such a substance as amyloid is, first, to decompose it and char it, driving off the volatile portions, and to leave a residue of conducting charcoal. Second, if the charcoal is carried to a very high temperature it becomes very much harder and more conducting, and seems to be converted into a modification possessing some of the properties of graphite.

If the material is merely converted into charcoal it is softer, and therefore more carbons are lost in handling, and it occludes gases and moisture, and the carbons are apt to fly to pieces on being "flashed." It is therefore very much better from that point of view to use a furnace that can give a white heat. But, on the other hand, the carbons can be very highly heated during flashing, and furnaces that give very high temperatures are more expensive to begin with, and cost more in fuel and in crucibles.

The effect of a very high temperature on carbon may easily be shown by comparing carbons that have been very highly heated with others that have merely been converted into conducting charcoal. If one of the latter is held in a gas flame it will glow and burn away at once. If one now be put in a vessel which is exhausted, or filled with coal gas at a very low pressure, and then raised by a current to a very white heat for a moment, it will be found quite altered. It will be quite hard and springy, and will have a steel-like ring. Its electrical resistance will be very much reduced, and it will no longer burn in the gas flame. It has also lost its power of occluding gases. The hardening and decrease of resistance when carbons are flashed have generally been supposed to be due to the deposition of carbon, and this is partly true; but the greater part of the effect is due to the high temperature. The resistance falls suddenly immediately the carbon is highly heated, and it goes on falling slowly owing to the deposition of carbon from the surrounding gas. The electrical resistance of carbon may be reduced even by maintaining a red heat for a long time. A carbon kept at a red heat will go on falling in resistance for some weeks.

The kind of furnace employed depends on the size of the factory. For a large one a reverberatory furnace, such as is used in iron works, is very satisfactory. A reverberatory furnace can be easily regulated to give any temperature up to the melting point of iron.

For smaller outputs a coke or gas furnace is better.

Coke furnaces, built up of pieces of fireclay, with iron binding to prevent their falling to pieces when cracked, can be got up to very large sizes. What are erroneously called reverberatory furnaces do very well. They are tumbler-shaped, with round tops, with necks for sheet-iron chimneys. They are made in three pieces. This kind of furnace will easily melt a file, and requires very little attention. On the other hand it takes a round or, more correctly, a cylindrical crucible, and it is not easy to pack carbons into such a shape closely. A large furnace is therefore necessary for a given output.

Gas furnaces are very much more convenient. Fletcher's reverberatory furnaces are very good. No doubt other gas furnaces are as good, but with Fletcher's gas apparatus results as good as, or better than, those given in the catalogue are always to be obtained. These reverberatory furnaces can be used either with a chimney draught or with a blast. The burners of the draught reverberatory furnaces give trouble if they are not carefully adjusted. Not the least advantage of gas is its cleanliness. Such a furnace as that described need not have a room to itself, but can be placed on an iron topped table in the thread room, and looked after by girls.

If the material is in the form of thread, such as squirted amyloid, it is wound on a rectangular frame made of two rods and two end pieces. The end pieces are flat slips with a hole in each end the size of the rods, so as to hold the rods stiffly. The thread is wound over the rods. The rods are earthenware, or preferably arc light carbons, as most kinds of earthenware crack. The side pieces must be made of some material that contracts when carbonised, otherwise the carbons would break, as they contract considerably. On the other hand, the side pieces must not contract too much, or the carbons will not be kept taut and will come out irregular in shape. For amyloid carbons, soft wood, such as deal, is about right. The deal should be cut with the grain of the wood lengthwise, for if it is cross-grained it will contract too much.

If the carbons are to have single loops, as generally used in low-resistance lamps, the frames may be so arranged that each turn makes two carbons, a little extra length being allowed for waste, and a large margin for contraction. It is generally better, however, to make the frames shorter, so that each turn makes one carbon. The carbons are then more likely to be well shaped. The thread is wound evenly on the frame by a traversing screw arrangement. Long, thin carbons cannot always be made in single hairpin loops, as they are then too long to go into a small lamp. Swan's well-known loop makes a very pretty lamp. It is got by giving the thread an extra turn round the rod of the frame. It is somewhat difficult to wind thread on frames so as to give this form. It can be done by hand by winding enough thread on a small reel to fill one frame, and passing it through every second turn. This does very well for experimental work, but it is too tedious for factory use. The thread can be wound on the frame by a suitable machine, and more or less complicated winders are in use. The rods are gripped by one end in a clamp, and one wooden end piece is pressed up against the clamp, so that the frame is like a two-pronged fork. The thread is wound by rotating the frame and a reel of thread, so as to give the desired motion by means of an ingenious application of the Geneva stop. The writer has devised a cheaper winder. The thread is wound on a reel with a nozzle, through which it is unwound. The reel and nozzle are so mounted that the nozzle turns round a centre, so that if one rod of a frame were there a continuous spiral would be wound on it. A screw feed moves the nozzle and reel along. Instead of remaining stationary the frame is turned on its own centre at only half the speed of the nozzle, so that two turns are wound on each rod alternately. A similar result can be obtained with a stationary reel and nozzle, and a modified sun and planet attachment carrying the frame. When the frame is nearly filled the thread is fastened, and the wooden end piece pressed on before the clamp is unscrewed.

For long thin carbons the rods may be made of large diameter. A very pretty shape is obtained by winding the loop over two rods instead of one, so that it is long. This shape fits a long shaped bulb best, while the Swan loop suits the round or nearly round form.

When the frames are wound they are wrapped in paper and placed in the crucible. Powdered charcoal mixed with lampblack is shaken down so as to fill up the interstices and cover the frames completely. The lid is then cemented down with fireclay. The object of the paper is to keep the carbon dust off the thread, as it is otherwise necessary to dust the carbons after carbonising, and all such processes as that, though they seem nothing on paper, absorb time and cost money, and lead to breakage and waste of carbons. If a high-temperature furnace is used the crucible must be made of fireclay or graphite. Morgan's are very good. They can be made in any reasonable form in three weeks or a month. For low temperatures cast-iron boxes are best.

The charcoal and lampblack are to prevent access of oxygen to the carbons. It is doubtful whether the lampblack is really necessary, and it is very dirty. New lampblack is often troublesome in another way; it is a very bad conductor of heat, and either prevents the crucible from cooling or takes fire at a very low temperature. The writer has seen fireclay crucibles, 14in. by 10in., which became red hot inside when opened after being removed from the furnace two days. Powdered charcoal alone is generally used. When charcoal or lampblack is heated very strongly over and over again it shrinks and hardens, and being less combustible at low tem-

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peratures, is no longer such perfect protection. The paper wrapped round the frames and the wooden end pieces are, however, sufficient, as they give off gases which make it impossible for the carbons themselves to be at all attacked by oxygen.

The final temperature reached by the furnace is not alone to be considered, the rate of heating is also very important. If the crucibles are heated rapidly the outsides become hot first, as the powdered charcoal is a very bad conductor of heat. The wooden end pieces of the frames are thus carbonised before the thread, and the result is that the rods are brought closer together before the thread begins to shrink. It is thus loosened, and shifts about on the frames, and it then contracts and breaks here and there, or finally comes out as very irregular carbons. Mr. A. Woodley, who was the writer's assistant and successor at the Swan Lamp Works in Boston, U.S.A., finally carbonised by heating the saggars or crucibles in the furnaces used for the manufacture of arc carbons. These furnaces were designed by Mr. Brush to admit of the most accurate regulation of the temperature throughout the firing. As Mr. Brush's furnaces—and, in fact, the whole of his processes of manufacture of arc light carbons—are kept secret, the writer will not publish any description. Mr. Woodley found carbons made by extending the rise of temperature over several days were very much more regular in shape, and more uniform in resistance than those made in a day.

Carbons made from amyloid sheets by punches, or from paper or other sheets, are carbonised by placing them in layers with a suitable material between. The material should have the same contraction as the blanks, and should not wrinkle up. Paper is generally unsatisfactory, as it wrinkles. Calico is about the best material; some calicoes, probably those which are sized, are troublesome, but are better after washing in water and drying flat. The blanks are punched with the ends joined together for support, as a flat horseshoe of such flimsy material would be very difficult to carbonise well if the ends were loose. It is not necessary to add powdered charcoal or lampblack to crucibles which are nearly filled with calico, as it thoroughly protects the carbons if the crucible lids are properly luted. A flat weight should rest on the calico, so as to keep it pressed out flat during carbonisation.

Silk gives great trouble in carbonising. It not only contracts very much, but it has to be heated at a particular rate. The carbon and wood frames, already described, are not suitable for silk thread, as it needs support along its length, or else it breaks or comes out crooked and uneven. Blocks of retort carbon, with one side or two opposite sides rounded, are used. The thread is wound on these in one layer, with about a sixteenth of an inch clearance between neighbouring turns. When a block is filled, soft cotton thread, such as fine knitting cotton, is wound over the block at right angles to the silk. This is wound tight enough to keep the silk straight, but not tight enough to prevent its shrinking lengthwise. After the cotton is wound on, the silk is cut by drawing a knife along the block, so that it becomes a number of loops tied gently over a carbon block. The blocks are then wrapped in paper and placed in the crucibles, with powdered charcoal over them.

The crucibles are then transferred to a gas oven, heated to a temperature at which paper begins to char, and are kept there for three or four hours. They are then put in the furnace and raised to a high temperature. The successful carbonisation of silk threads requires great patience and considerable practice. Fine threads are very apt to be drawn flat or weakened at the arch. Thick carbons for low-resistance lamps give no trouble.

The blocks or frames should nearly fill the crucible, so that they cannot fall about and damage the delicate carbons. Pieces of millboard about the same size as the frames may be put against them before wrapping the frames in paper. This prevents anything coming in contact with the carbons during the carbonisation.

The furnace may be cooled at any rate, as that does not affect the carbons. Slowness of heating secures good and regular shapes, and high temperature, or long-continued firing, makes the carbons hard and durable, and of low specific resistance.

After unpacking, the carbons should be carefully dusted, if at all dusty, as small particles of charcoal powder may otherwise adhere, and these will cause irregularities in flashing, as the carbon is deposited more thickly on excrescences.

Blacklead should not be used as a substitute for powdered charcoal, as it does not protect the carbons, for graphite only combines with oxygen at a high temperature.

THE STEAM ENGINE INDICATOR.—XIX.*

BY AMICE.

Before proceeding further in our treatment of the diagrams from compound engines, we must take a practical example of the transfer of diagrams as taken by the indicator with different springs to corresponding diagrams of the same scale of pressures and volumes. This has been referred to with reference to Fig. 50, and at more length to Fig. 59. In the latter, the effect on the diagram of different and of the same clearance spaces was shown, with a method of ascertaining the theoretic clearance when the actual clearance was not known. One of the few recent complete tests of an ordinary small compound engine, of the type shown by Fig. 44, namely, that made with one of Messrs. Davey, Paxman and Co.'s engines, as described in our impression of the 26th November, 1886, provides us with a set of diagrams in connection with which all the data are known. The trial was carried out by the late Mr. W. E. Rich, M. Inst. C.E., and Prof. Kennedy. The engine was one which had been driving dynamo-electric machinery at three successive Exhibitions, namely, the Health, the Inventions, and the Colonial, and after all this work gave the excellent results which have been recorded. The principal particulars and dimensions of the engine are :—

Diameter of high-pressure cylinder	12·28in.
„ low „	20·08in.
Area of high-pressure cylinder...............	118·25in.
„ low „	315·50in.
Stroke of pistons	2ft.
Revolutions per minute........................	109·5
Boiler pressure	107lb.
Indicated horse-power	109·5
Nominal horse-power..........................	40·0
Water consumed per ind. h.-p. per hour ...	24·15lb.
Coal, Welsh „ „ „ ...	2·56lb.

The engine was fitted with Paxman's automatic cut-off expansion gear. From this engine high and low-pressure diagrams were taken at regular intervals during the trial and simultaneously from both cylinders. Figs. 60 and 61 are engraved from one set.

There is some difference between the two diagrams from either end of both the high and low-pressure cylinders, but both are very good. The admission of the steam to the front end appears to be much better than at the back end, as, although a horizontal admission line is not obtained, the pressure reaches much nearer to that in the boiler. The closing of the valve took place somewhat slowly. The admission line at the back end is apparently better, but is not really any better, for the approach to a horizontal line is only obtained at the expense of a full admission in the earliest part of the stroke, the highest pressure at the front end being about 98lb., whilst that at the back end is about 10lb. less. Thus, without knowing the difference between boiler pressure and cylinder pressure, a diagram which may really indicate a restricted admission may appear better, or seem to indicate better performance, than one which has a descending admission line and belongs really to a better performance. Cut-off takes place in these diagrams at about half stroke, and the expansion follows approximately the hyperbolic or what is generally spoken of as the isothermal expansion curve. The exhaust of the front end diagram will be seen to take place more nearly at the pressure in the small receiver—which consists in the space between the cylinders—than in the back diagram, which would appear to be due to the admission of more steam to the back end than to the front end. The lower or exhaust line of both diagrams shows the effect of the rise in pressure in

* For Art. 18, see *The Electrician*, 25th June, 1886, p. 129

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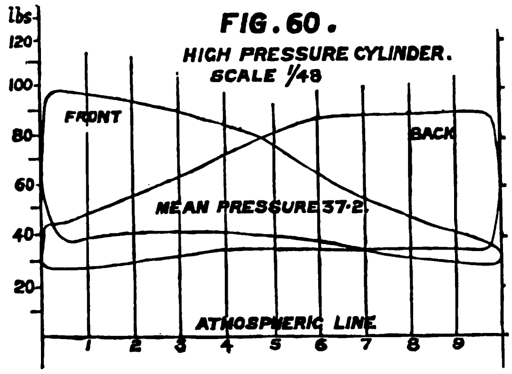
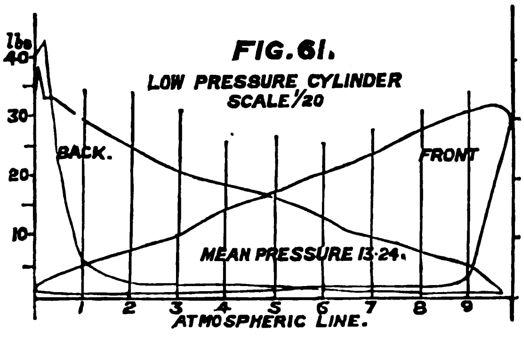
the cylinder as the low-pressure piston approaches the end of its stroke, and thus causes rise in the receiver pressure, and consequently in the back pressure against the high-pressure piston. The amount of compression is small at either end.

In the low-pressure cylinder (see diagrams, Fig. 61, taken with 20lb. spring) the amount of compression adopted is very considerable, and especially at the back end, where it carries the pressure considerably above that in the receiver, from which it drops by the opening of the valve exactly at the end of the stroke, thus forming the loop shown. Judging by the back pressure shown by the low-pressure diagrams, although only about 2·5lb., somewhat larger exhaust ports in the port face and valve would be advantageous. It is not, however, without diffidence that any such comment is made, for the efficiency of the engine is remarkably high, as shown by the figures which are given below the diagram, Fig. 62. The evident freedom of the exhaust at the commencement of the stroke may, perhaps, suggest a little hesitation on this point. It may, moreover, be remarked that, although it is supposed that the super-heating of the exhaust steam in the smoke box and chimney tend to reduce back pressure, it is not at all so certain that this is the case, although for other reasons economy may result from this position of the exhaust pipe.





We now come to the high and low-pressure diagrams, Fig. 62, as plotted from those we have been discussing, so as to give them the relative forms and areas they would have if taken from one cylinder, except for the gap which occurs through the performance of the expansion in two stages. The enlargement and combination in this manner affords a picture of the steam performance, which is instructive in many respects.

In setting out these combined or expanded diagrams, as they are often called, we first ascertain the cubic capacity of the two cylinders, including their clearance. In the case before us the volumes are 1·7 and 4·55 cubic feet, and of these the clearance represents about 0·08 and 0·2 cubic feet respectively, or about 4·5 per cent. and 6 per cent respectively, the diameters of the cylinders being 12·28 and 20·03, and their areas 118·3 and 315·5. We now draw a vertical line, EE′, and divide it into some convenient scale representing lbs. per square inch, say a quarter inch to the lb., carrying the scale sufficiently high to include the highest pressure occurring in the high-pressure cylinder, or, say, the boiler pressure. In our case we are dealing with a non-condensing engine, and therefore with pressure above that of the atmosphere, which will be our zero. For constructive purposes we must, however, carry our scale to the vacuum line or absolute zero 14·74lb. below that of the atmosphere. At the atmospheric pressure line we draw the horizontal line A L. We may also draw the line E F at the level of the boiler-pressure, which in this case is 107lb. We now divide the lines E F and A L by a scale which shall represent volumes, or the capacity of the cylinders in cubic feet; that of the low-pressure cylinder being 4·55 cubic feet we divide the lines into 4·55 parts. Now, from the line A L near A we draw the light lines *c* and *c′*, at distances from the line E F which shall represent the volumes of the clearance spaces and ports, namely 0·08 and 0·2ft. We next draw a light line, *d l*, at the level of the lowest pressure in the high-pressure cylinder, as shown by the diagram in Fig. 60, taking that from the front end. On this line set off the length, equal 1·7 cubic feet, and from line C divide this into 10 parts. Similarly divide the line A L from line C′ = 4·55ft. into 10 parts. From each of the 10 divisions on *d l* draw light vertical ordinates, and similarly from each of the divisions on the lines AL. Now, having divided the diagrams in Figs. 60 and 61 into 10 equal parts, we may transfer the pressures shown on each of these divisions to our new expanded diagram lines. For instance, on the line C we set off the 97lb. found on the front end of Fig. 60, and also the lower pressure of 36lb. On the vertical

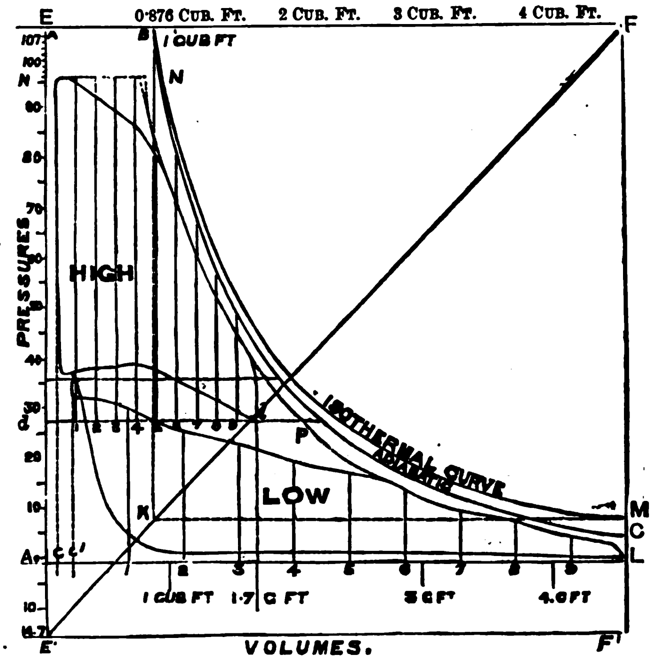


FIG. 62.

Diagrams from 40 H.-P. Semi-fixed Engine, by DAVEY, PAXMAN and Co., *Indicating 109·5 I.-H.-P.*

High-pressure Cylinder	12·28in.
Low-pressure Cylinder	20·03in.
Stroke	24·0 in.
Revolutions per minute	104
Pressure in Boiler	107 lbs.
Water per I.-H.-P. per hour	24·15lbs.
Coal per I.-H.-P. per hour	2·56lbs.

Trial 27th October, 1886.

ordinate 1 of this high-pressure diagram we see that the highest pressure was 95lb., and the lower 37lb. These we set off ordinate 1 of the new high-pressure diagram. Similarly, we set off the pressures on the remaining ordinates 2, 3, 4, &c., until having 22 points at the upper and the lower ends of these pressure ordinates we have only to connect them to complete this diagram. In constructing the low-pressure expanded diagram, we take as the higher pressure on line C′ the height of the loop at the commencement of the stroke, namely 37lb., and the lower part of the loop, namely 33lb., and on ordinate 1 we find the pressures shown were 30 and 7, and we set these off on the corresponding ordinate, on Fig. 62, until the diagram, and similarly the pressure on the other 9 ordinates, is completed. We have now the two diagrams in their true proportions rela-

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tive to those of the cylinders and the pressures in them, and can compare the behaviour of the steam in the cylinders with that which would theoretically be the behaviour in a non-conducting cylinder. Knowing the point at which steam was cut off we can mark the volume of steam admitted to the high-pressure cylinder, plus that which is necessary to fill the clearance spaces on the line E F. The volume in this case is 0·876 cubic feet, as marked on the line E F at B. From this point we may set out the hyperbolic or so-called isothermal expansion curve B M in the manner explained with reference to Figs. 36, 38, and 40,* or the adiabatic curve B C, as described with reference to Fig. 41.† The area not filled by the diagrams between A L C N N may be said to be due to the losses which occur in the practical engine, chiefly due to condensation from different causes, only a comparatively small part being due to the performance of work. The largest area is that of the gap between the diagrams and within the dotted line P.

LITERATURE.

The Electric Motor and its Application. By T. C. Martin and J. Wetzler, Associate Editors of the *Electrical Review*. [New York: W. J. Johnston.]

Among all the developments of modern industrial science it would be difficult to name a single application which possesses so great an interest as the electric motor. This interest arises in part from its past history, and the long period of development (or at least modification), during which its exact function as a translator rather than a producer of energy was ill-understood. It arises in part from its present position, in that its field of usefulness has quite recently received such great and important extensions. And the charm of the subject arises still more, perhaps, from the sense of the great but ill-defined possibilities of the future. The story of the origin, the rise and progress, of the electric motor is well told in the book before us. As regards the early history of the subject, the names of the workers upon this side of the ocean are household words with us. Barlow with his wheel, Jacobi sailing on the Neva, Pacinotti with his ring, are pictures that arise at once in our minds. But the authors of this work, with a proper regard for the honour of their own country, have brought before us in Chapter III. the claims of many ingenious Americans who deserve, at least to share the credit that is due to the early explorer. Of these, the oldest and not the least creditable attempt dates back to the very same year (1834) when Jacobi made his first successful motor. This American pioneer was a Vermont blacksmith named Davenport, of whom some account will be found in the volumes of this journal for the year 1882. The records of the United States Patent Office furnish the names of sixteen inventors who were at work during the earlier period, of which probably the most worthy of recollection are Page, Vergnes, and Farmer.

Coming, then, to modern times we find the history of the recent development both in Europe and America very fully set forth in these pages, and with plentiful illustrations, executed in the usual and admirable style of American engravings. There is less need to enter upon a criticism of these chapters, inasmuch as they are for the most part avowedly reprints from the *Electrical World* and other technical journals, and, indeed, we have not discovered any facts of importance which have not already appeared in our own columns.

We may mention in passing that the number of electric railways described exceeds 40, of which only eight make use of storage cells. No less than 60 motors of different types are described and illustrated, of which rather more than one half are of modern date. The "Immisch" motor seems to be the only one of importance that is not discussed.

From what has been already said, it will be gathered that the descriptive and historical chapters, which form by far the greater portion of this work, contain a valuable and, no doubt, a trustworthy record of facts, and if placed together with Mr. Gisbert Kapp's theoretical work "On the Electrical Transmission of Power" we should possess very nearly all that can for the present be said upon the subject. Unfortunately, the same meed of praise cannot be awarded to much of the theoretical treatment of the subject. Native American genius scarcely seems to thrive however in the more arid atmosphere of theoretical discussion. So far as these chapters are taken from the writings of Prof. S. P. Thompson and of Mr. Kapp, of course these remarks do not apply. In Chapter III. we are presented with what appears to be a reprint of a paper by Mr. Thomas Rae, consisting of the numerical discussion of an installation for the transmission of 500 horse-power to a distance of 4,000 yards (2·27 miles). This calculation will no doubt be studied with much attention, especially in America, and we, therefore, conceive it to be the more desirable to draw attention to the very serious errors which it contains. Mr. Rae *assumes*, to begin with, that the sectional area of the conductor is to be 3·25 square inches, and that the potential at the terminals of the dynamo is not to exceed 120 volts. Allowing 85 per cent. for the efficiency of the conversion of the 500 horse-power, it is calculated that the current in the mains will be 2,642 amperes. Mr. Rae then proposes to prove that this current will not unduly heat the main, and after showing that upon this question he is alive to the influence of the character of the insulation, and of the surrounding medium, he writes as follows:—"In such circumstances [uncertainty of exact conditions of envelopment] the only recourse is to general formulæ, as furnishing, all things considered, as fair an average of the conflicting influences as possible, and one of Clerk and Sabine will do as well as any. It is

$$\theta = 0{\cdot}2405\ R\ C^2 t.$$

In which θ = units of heat,
R = resistance in ohms (in this case for the entire 4,000 yards we have R = ·035 ohm),
C = current in amperes,
t = time in seconds.

Since the current in this case is practically continuous, t will disappear (!) and . . . . it will be found that $\theta = 58{,}736$ units of heat." It is then shown that this quantity of heat corresponds for the given weight of copper to a rise of temperature of only 4·17°F. But it need hardly be pointed out to the English reader that the calculation is entirely misleading, being in fact quite incomplete. In order to determine the temperature which will be attained by the copper we must know not only the rate at which heat is being generated, but also the rate at which it is dissipated by radiation. And as the rate of radiation increases with the temperature the latter will continue to rise until the heat radiated per second is exactly equal to the heat generated in the same time, and not until this is the case will the temperature cease to rise. The proper method of treating the problem is sufficiently well known, and has been discussed at length by Prof. Forbes in the paper which he read before the Society of Telegraph-Engineers and Electricians on March 27th, 1884. From the data established in this paper it may be shown that the actual rise (in the case of a bare copper wire blackened to increase the radiation) would exceed 50° F. If this were all, however, Mr. Rae's mistake would be of little importance; but having thus come to the conclusion that the rise of temperature in the conductor is trifling he evidently thought it was unnecessary to calculate the energy lost in the leads; nevertheless, still wishing to be reasonably accurate, he proceeds to consider the *increase* of resistance due to the rise of temperature of 4·17 F. Without, however, following Mr. Rae into such minutiæ, we may venture to point out that a current of 2,642 amperes through a resistance of ·035 ohm involves a loss of rather more than 300 horse-power, or about 70 per cent. of the whole energy available at the terminals of his dynamo. In fact, at the end of the line the difference of potential will have been reduced to only 28 volts.

This little correction tends, we fear, somewhat to discount the value of Mr. Rae's subsequent calculations. We must, however, refer, in conclusion, to the utterly misleading practice adopted in this case and by other American electricians, of calculating the energy available (and saleable) at the end of a long line upon the basis solely of the current.

* *The Electrician*, Dec. 18, 1885. † *The Electrician*, Dec. 25, 1885.

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Even if the potential be constant at the terminals of the machine, it need hardly be said that unless the resistance of the line is negligible the work done at the further end is *not* proportionate merely to the current.

Time alone can reveal what the future of the electric motor may be. At present he would be a rash man who would attempt to set a limit to its possibilities of usefulness. But, however great may be the extensions of the future, and notwithstanding the defects to which we have alluded, this book will long hold a place as an historical memoir of its earlier development.

CORRESPONDENCE.

HEATING OF CORES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the issue of February 4th of your valuable paper you publish an article on the energy dissipated in an iron core submitted to magnetisation in rapidly alternating directions, where the view is set forth that the larger part, or nearly the whole, of the heat evolved in the core is due to the Foucault currents, and that the internal friction of the particles of the iron causes only a small quantity of heat to be generated. As this question is of the utmost importance in the designing of transformers and of all apparatus to be worked in connection with alternating electric currents, a very extensive series of investigations on this subject was carried on in the last three years by myself and Mr. Neustadt, at the works of Messrs. Ganz and Company, at Budapest. A large number of differently made iron cores, varying in weight from 10 to 250 pounds, were submitted to the action of alternating electric currents of from 50 to 200 reversals of direction per second. The magnetic induction reached often the very high value of 30,000 units, and the energy consumed in the iron core amounted sometimes to 4 horse-power. It was exactly measured by aid of a watt meter I designed for the purpose, which is a suitable modification of the Siemens electro-dynamometer, the influence of the self-induction on the accuracy of the results being reduced to a very small fraction of 1 per cent.

The deductions drawn from these experiments on such a large scale corroborate in a very marked degree the results obtained by Dr. John Hopkinson in his researches "On Magnetisation of Iron" (paper contributed in 1885 to the Royal Society). It may be seen there that the energy dissipated by magnetic friction is an important quantity; indeed, in any well designed transformer it will always be considerably more than the amount of heat evolved by the Foucault currents in the iron core. For example, in the standard 10 horse-power transformer manufactured by Messrs. Ganz and Co, the Foucault currents in the core will only consume about 50 watts, while the magnetic friction amounts to 150 watts.

The highest figure found for the energy consumed in one pound of iron for one reversal of the direction of magnetisation was 0·07 volt-coulomb, or 700,000 ergs.—Yours, &c.,

Treviso, Feb. 12, 1887. OTTO T. BLATHY.

[We should be much interested to learn in what way the experiments referred to by our correspondent were actually carried out. The evidence on either side seems to be somewhat conflicting. Prof. Ewing, in a paper on "Magnetic Hysteresis" (read before the Royal Society, January, 1885), states that, "while the dissipation of energy by reversal of magnetism is very much smaller in soft iron than in hard iron or steel, even in the latter its amount is very trifling, so that the principal part of the heat which is produced in the cores of electro-magnets must be due chiefly to other causes than this static hysteresis, and is, in fact, due almost wholly to the induction of so-called Foucault currents in the cores." Our correspondent refers to Dr. Hopkinson as an authority for the opposite view, but we have been unable to discover the passage to which reference is made in Dr. Hopkinson's paper on the "Magnetisation of Iron." The question is one which will bear further discussion.—ED. *E.*]

THE ELECTRICAL TRANSMISSION OF 500 HORSE-POWER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter of your correspondent "Enquirer" does not contain sufficient details to enable an exact estimate to be framed, but the following may be taken as a first approximation. It is not clear from "Enquirer's" letter whether the 500 horse-power to be *transmitted* is the brake horse-power of the motor, or whether it be the available energy of the turbines. We will assume the latter to be intended. The problem now is, given 500 horse-power on dynamo shaft, what horse-power can the motor usefully develop? We will use a series-wound dynamo and a series-wound motor. Each machine must have a suitable resistance as a shunt to the field coils. These resistances will be used, as occasion may require, for starting the machines, or for varying the speeds to suit different loads.

The efficiency of conversion of both dynamo and motor may be taken as certainly not less than 90 per cent. The dynamo will thus give in the outer circuit 450 horse-power = 335,700 watts. Let the terminal difference of potential be 2,000 volts; the current will then be 168 amperes.

The distance between the generator and receiver is 800ft. This gives about 1,600ft. of cable.

Let the cable have a cross section of ·178 square inch, and be of silicium bronze. The resistance will be about ·073 ohms at 60°Fah.

The loss in this resistance will be roughly 3 electrical horse-power. The weight of the cable will be approximately 1,100lb., if we neglect insulation. The cost will be about £100, assuming the cable to be insulated and armoured for one-half of the distance only.

The electrical energy given to the motor will be about 333,600 watts; and if 90 per cent. of this be given out as useful work, the horse-power of the motor will be 405.

The commercial efficiency of the system, dating from the power supplied to the dynamo, will therefore be $\frac{405}{500} = 80$ per cent. about.

We should, for our own part, be pleased to enter further into the financial details, but we presume that you, Mr. Editor, would tell us that your correspondence columns are not the proper place for tenders.—Yours, &c.,

M. IMMISCH AND CO.
(per Albion T. Snell).

Malden Works, Malden-crescent, Kentish Town, London.

FIRE INSURANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would one of your correspondents or yourself be kind enough to explain the reason for the American fire offices forbidding the use of resin as a flux for soldering electric light wires (see p. 458, Vol. XVII. *The Electrician*), and enforcing the use of acid (killed spirit). The contrary seems to be the English practice, the reason given being the corrosion of the wires and creeping of the acid. Unless there is a good reason for this action it seems a risky thing to do with the high tension multiple series systems so much used in the States.

Would you also oblige by stating whether Sir D. Salomons' pamphlet on "Secondary Batteries" is for private circulation or public; if the latter, where it can be obtained, and the price?

Apologising for troubling you.—Yours, &c.,

Feb. 11, 1887. G. T. PARDOE.

POLLAK CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can any of your subscribers tell me where the Pollak cells can be purchased, and whether they are suitable for some of the purposes that Grove cells are usually employed for in laboratories, such as exciting large electro-magnets and working coils?—Yours, &c., ASHLEIGH.

Ashleigh, Dorking, Surrey, Feb. 14, 1887.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CITY NOTES.

Our readers will find these Notes separate from the more technical and News Notes, and placed together after reports of meetings.

CONTENTS.

Notes ... 319
Incandescent Lamp Manufacture.—VIII. By J. Swinburne 323
The Steam Engine Indicator. XIX.—By Amice. Illustrated ... 324
Literature ... 326
Correspondence ... 327
FRANCE AND OCEAN CABLES... 328
GAS AND ITS PARTISANS ... 329
"Acheson" Duplex Wire. Illustrated ... 330
A New "Edison" Wire Gauge. 330
Society of Telegraph-Engineers and Electricians ... 332
Discussion in the French Chamber on Telegraphs ... 334
Legal Intelligence ... 336
Companies' Meetings—
Submarine Telegraph Co. ... 338
Anglo-American Brush Electric Light Corporation ... 339
Swan United Electric Light Co. 340
City Notes, &c. ... 340
Companies' Share List ... 340
Traffic Receipts ... 340

FRANCE AND OCEAN CABLES.

We have had some hesitation in dealing with a question which seems to have developed in French official circles an acute attack of Anglophobia, but the statements that have been made, and the conclusions arrived at from these statements, are so erroneous that it is absolutely necessary to speak with no uncertain voice. The French Chamber has a difficult task before it, as must always be the case when the subject under discussion is technical and complicated; but from the very able speech of M. LUCIEN DE LA FERRIÈRE it is quite certain that all technicalities and complications will be simplified and made as clear as possible, so that the decision arrived at may be final and complete.

Comparisons are proverbially odious, yet it will be well to recall at the present time the position that France took in the early days of submarine telegraphy. The position may be said to have been one of cordial sympathy with those earnest advocates of the practicability of cable work, while somewhat dubious as to its pecuniary success. France, in fact, eagerly welcomed the practical test, but declined to take part in the necessary cost. The value of progress was admitted, but the individual investment was too risky. Hence, after plans had been discussed both by the French and English Governments in the years 1848-1849, LOUIS NAPOLEON and the Minister of the Interior M. DUFAURE, in 1850 signed a concession granted to Messrs. J. BRETT, LOCKE and Co., for the right to lay an electric telegraph line between France and England by a submarine communication across the Channel. History tells us the first line was laid in 1850 and almost immediately failed. The requisite capital for another attempt was obtained in England, and this attempt succeeded. It was but natural that the men who encountered and overcame the initial monetary and practical difficulties should continue to give their attention to cable work, and just as natural that other cables were laid under their auspices. Thus cable work developed in England, factories were started, the various requirements of the work were studied, large sums of money were lost in attempts which again and again failed, and only finally succeeded by indomitable pluck and perseverance.

Ships were specially planned, built, and fitted with carefully designed apparatus for this particular work, till success became the rule and not the exception. In these early days strong and protracted efforts were made over and over again to induce French and American investors to assist the English capitalists, and we must emphasise the fact that it was solely because of their unwillingness that the major part of the cable work of the world has been carried out by, and is now under the control of, English companies. Were English capitalists who believed they saw a way to profitably use their money to sit still because France or America, or any other country, thought the investment unsafe? Were they not, rather, justified in using their capital to connect every commercial centre in a great network of cables from which they thought telegraphic custom would come? The question of colonial dependencies and mother countries in those early days had little weight; the important question was the obtainable business between the points to be connected. We have thus briefly and imperfectly shown that the development of cable work in English hands was, under the circumstances, inevitable. France has in the end obtained as many advantages from the success of Submarine Cable enterprise as the people who carried out the work.

In our issue of July 16, 1886, we called attention to a scheme promoted by a Count D'OKSZA, by which the French Government was asked to subsidise a line to connect Brazil with the United States and various French colonies. The discussion on this scheme, then adjourned, has been recently resumed, and, singular to say, with the result that the Minister of Posts and Telegraphs, M. GRANET, and one or two minor officials have given it their official support, and striven to get it adopted by means of erroneous statistics, and violent attacks upon England and English companies. The advocates of the scheme base their support upon the patriotic pedestal. They would—at the expense of the taxpayer—create cable factories and educational establishments, build ships, and gain experience in laying and repairing cables, possibly, like the English, by numerous costly failures. They would have the French colonies connected with France at a ruinous cost, even if only half-a-dozen messages per annum were carried by the cables. These gentlemen want too much and go too far; so that it is certain the Chamber will never lend itself to such an enterprise. It is really astounding that a Minister of Posts and Telegraphs could be found to lend himself to the support of so feeble a project. Let us consider more closely the reasons given for this proposition. France desires a new industry, a submarine cable industry. We have shown why the industry has not developed in France. England would like the wine industry that France glories in; but all the subsidies of all the Parliaments in creation will not give it. France wants her colonies connected direct and through no foreign soil. The projected cable starts from Pará, in Brazil, touches Cayenne, Paramaribo, Martinique, Guadaloupe, Mona, Puerto-Plata, to New York, where it joins the Brest Atlantic cable. Branches will connect Curaçoa, Caracas, and Panama. Here is a scheme for ten thousand miles, more or less, of single cable, a large portion of which is to be in seas where English enterprise has failed to keep a cable at work after it has been laid. And is it to be supposed that such a cable will be long intact? If it is broken, what becomes of the grand scheme? Now as to the patriotic idea of direct cables. Surely if France is

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so enamoured of it, how much more ought England to be? Yet with some amount of diffidence we would ask, how does England really stand? Are we not almost everywhere dependent upon the use of foreign territories? We go through France to India, *viâ* Cochin China to China, *viâ* Java to Australia, *viâ* Portugal to Brazil, *viâ* the States to the West Indies. England is in direct communication with the United States; so is France. A glance at the map of the world will show that for France to have an entirely independent system the cost must be reckoned by tens of millions of pounds, and, in fact, an enormous expenditure would be required to make England similarly independent, even with the network of her cables as they now exist. Before referring to the purely business aspect of the case, we would say that the statements made by the supporters of this scheme with regard to Tonquin, &c., are wholly unjust and unwarranted. With regard to Cochin China, landing at Cape St. Jacques was at first refused, but subsequently permitted, without subsidy or privilege, at the earnest request of a deputation, one of the members of this deputation being the present member for Tonquin, M. BLANSCUBÉ, who is now opposing the English company, and echoing the cry that all must be French, of French make, and worked by French clerks. The connection with Tonquin is really a short section in the midst of thousands of miles of cable previously laid by private companies without any Government aid whatever. The section was laid, to the great advantage of French interests, in the most economical manner, with a subsidy based on a five per cent. interest. The director of this section is a Frenchman, and so highly have his services been appreciated that he has been decorated by the French Government with several orders. So far as we can gather, it is the custom of the English companies to employ, as much as possible, natives of the country in which the stations are placed. One more brief reference to this foreign soil scare. Memory must indeed be short if the value of the Eastern Company's cables from Marseilles to Malta, and from Malta to England, and the cables from England to France, when the French land lines were dominated by a foreign invader, are forgotten. These cables were almost the only means of communication between the north and south of France and the world outside, and the Government of the National Defence gratefully acknowledged their value.

From a business point of view these projected cables are not wanted, in that the greater portion of the district is already provided with cables. Certain connections could be made to join existing lines and fill up the gap, and these have, we believe, been offered for a subsidy of some 94,500fr., and Government messages at half rates, instead of the 1,000,000fr. required by M. GRANET'S scheme. It may be taken for granted that every farthing of the subsidy would be required, for though the traffic might be increased by the decrease of tariffs under competition, the business transactions are and cannot but be far too limited to pay expenses. It is possible to obtain exact figures as to business done with the French colonies now having cable connections. Taking Guadaloupe and Martinique, the traffic to and from France in 1885 from these colonies amounted to less than three messages per day. Messages between America and these islands averaged about five per week, and from the Brazils the total reached three in the whole year. Surely men possessing the faintest grasp of business principles must see that duplicating these cable connections, even with fighting traffic rates, cannot possibly make the business remunerative.

Would it not be better if this great submarine telegraph system, which now touches every centre of civilisation and commerce throughout the world, were looked upon—as the French Government have so often been asked to regard it—as a great International cable system in which they hold certain links, from the whole of which they derive the same advantages as England and the other nations of the world, and in which the important telegraph companies would be only too glad to have their co-operation and support. The French Government must be aware that to enter into competition with the existing system, or to make themselves independent of it, would be practically impossible. It would involve an outlay of at least twenty millions sterling, and then there would be no absolute security in case of war. Uniting themselves with the existing system would also be another important connection between France and England, and tend to strengthen those relations which it is so desirable should be strengthened in the interest of that peace and friendship which are so essential to the progress of both nations.

GAS AND ITS PARTISANS.

The editor of a provincial newspaper called the *Cornish Telegraph* has been at the pains, as he says, to obtain some "reliable information as to the relative cost of gas and the electric light." It is not precisely stated what sources of information have been applied to; but as he has published only the opinion of the editor of the *Gas Engineer*, we are compelled to infer that his other informants were of the same mind; and that, this being so, it is safe also to infer that he addressed no inquiries to the editor of any electrical newspaper whatever, nor to any electrical engineer whose opinion was worth having. In fact, the editor of the *Cornish Telegraph* appears to have wanted information of a particular kind, and he got exactly what he wanted. Why the Cornish editor or proprietor is so ready to publish a one-sided view of the electric light, furnished from a quarter known to be hostile to it, we can only leave to conjecture. But we happen to know that there is an electric light installation of some importance on the *tapis* in the South-west of England just now; and local sources of information adverse to the scheme failing him, the Cornish editor may have sent to London for one of those stereotyped articles which journals devoted to the gas interests keep ready for the provincial consumer. We do not quarrel with the local newspaper proprietor on this account; he conducts his commercial affairs on the same principles as his political. The *Cornish Telegraph*, we notice, is a Home Ruler, and is content to accept "reliable information" on that subject from the *Daily News*. Similarly, when it wants to discredit Electric Lighting, the *Cornish Telegraph* quotes the *Gas Engineer*. This, as things go, is what we have to expect; but none the less it is our business to criticise the "reliable" information obtained in that way, and to test the impartiality of the editor who "fairly" embodies it as the result of his inquiries. We do not ask him to treat us as disinterested parties; but he cannot deny that we know more of our own business than any Gas Journal can tell him; and we claim this other merit, namely, that we do not pretend to know the business of the Gas Companies, and never say anything in disparagement of it except in defence of our own.

In defence of our own business, even on this occasion, we have no need to question the good faith of the *Gas Engineer*, or to dispute altogether the facts which seem to have given the editor of the *Cornish Telegraph* so much satisfaction. What we do say is that the facts adduced are for the most part irrelevant, and that the inferences drawn from them are greatly misleading. It is alleged that no reliable figures as to the cost of Electric Lighting are obtainable in this country, yet published informa-

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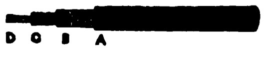
tion from American sources is accepted without question, and apparently without reflection. Because Electric Light in America is charged at a rate equivalent to 7s. 6d. or 8s. per 1,000ft. of gas, it is argued that this is what the illuminant will cost in England. Surely the *Gas Engineer* ought to know that the price of gas in America, as elsewhere, depends on the cost of coal; and, as the cost of producing electricity for illuminating purposes depends largely also on the price of coal, the legitimate inference would be that in England, where coal is so much cheaper, the necessary cost of supplying the new illuminant will be proportionately low. In America, we are told, the price of gas is frequently as high as 10s. per 1,000ft. Electric Lighting can be supplied there for less; and the result is that every week we are announcing that Gas manufacturers in the States are taking up the business of Electric Lighting as well. In England the price of coal varies considerably in different parts of the country; but where the conditions in this respect are favourable we have not the least doubt that our Gas Companies in due course will adopt the same policy. American information, therefore, even of the kind regarded as "reliable" by our opponents, tells rather favourably for the prospects of Electric Lighting here.

Of the few examples cited from experience in this country we need only say that the method of comparison seems to be to include the cost of plant in the case of Electric Lighting installations, but to exclude it in the case of Gas Lighting. For an isolated installation the necessary engines and dynamos tell heavily on the original outlay for the former; but so it would upon Gas Lighting if the undertaking were isolated and without connection with a central main. Yet our columns continually testify to the fact that isolated installations, if on a tolerably large scale, can be worked at an expenditure not greater than was previously demanded for the gas which electricity has superseded. As to the undertakers losing money by it, really they must be allowed to know their own business best; and for our part we no more suspect them of working as pure philanthropists than we suspect the Gas Companies of supplying gas at 3s. 6d. per thousand when it really costs them four shillings. The *Gas Engineer* professes to complain of the reticence maintained by its rivals in respect to the cost of Electric Lighting, and declares that "it is chiefly this reticence that is hindering the introduction of the new light." We are sorry we cannot accept these admonitions as altogether sincere. At all events, we are prepared to give the fullest information available whenever we are applied to. There is a reticence of inquiry as well as a reticence of answer; and it is pretty plain that the strictest economy has been exercised in selecting facts and arguments for the particular case in which the *Cornish Telegraph* seems to be so profoundly interested.

"ACHESON" DUPLEX WIRE.

We have received a sample of the Acheson duplex wire, to which we made some reference in our issue of the 14th January. This wire is now being made by the Westinghouse Company of the United States. In the figure, which is full



size, A is the outer covering of woven cotton treated with Japan paint, B is the hollow cylinder of electrolytically deposited copper which forms one of the conductors, C is an insulating coating of gutta percha, and D is the inner wire.

A NEW "EDISON" WIRE GAUGE.

The Edison Company of the United States have recently prepared for their own use a new "standard" wire gauge, which has been issued together with the circular which we give below. If this were actually the first wire gauge to be promulgated, it would, perhaps, be possible to criticise it with greater sympathy; as it is, we fear that the introduction of one more gauge, whatever its individual merits may happen to be, will chiefly tend to make confusion worse confounded. The introduction of a larger number of gauges for the heavier wires is an undeniable advantage, although the greater use of stranded wires in this country tends to minimise it advantages. In any case it will, however, be of interest to English electricians to learn the details of American practice in the important matter of current densities allowed. We do not know upon what basis the formula for the maximum safe current has been obtained—probably it is of an empirical character. It is, however, worthy of note that it will be found on trial that the numbers given in the table are in very close agreement with the results obtained by applying the formulæ given by Prof. Forbes for insulated cables (*Journal* Soc. Tel. Eng., May, 1884), if we make the supposition that the diameter of the cable is four times that of the conductor; assuming also, as is done by the Edison Company, that the rise of temperature permissible is in all cases equal to 35 deg. C.

On the other hand, so far as the smaller wires are concerned, it will be seen that the current given as "safe" very considerably exceeds the density which it is either usual or economical to employ in practice. Taking the size numbered 3 it will be found that the "safe" current is equivalent to over 5,400 amperes on the square inch, and involves the loss of a volt in every 23 yards run. As it is expressly stated that the table is meant to apply to house wires as well as to main leads, it is somewhat singular that No. 3 is the smallest wire included. From the column which we have added for comparison with the B.W.G. it will be seen that this size, which is permitted to carry 12·5 amperes, lies between Nos. 17 and 18 B.W.G. If, however, the Edison Company make it a rule not to use any wire smaller than this, the error, if any, is undeniably upon the right side. The circular of the company is as follows:—

"The large experience gained by the Edison Company in their past work has shown that in the calculation of large conductors the total number of sizes represented by all the gauges heretofore used in this country has been too limited, and the mass of copper represented by the largest of them is often insufficient to give the capacity desired. In consequence of this small number of regular sizes, it is very often impossible to avoid a waste of material and at the same time to secure sufficient conductivity, because a wire of any existing gauge sufficiently large to convey a maximum current economically may be considerably heavier per mile than one of a cross-section just adequate to give the proper per cent. of loss. In other words, in many cases one of the present sizes may give too great a loss, and the next larger (of any existing gauge) too small a percentage for true economy in operation. In this way thousands of dollars have probably been expended needlessly in copper in this country in the development of electric lighting, and imperfect distribution has often resulted.

"The Edison Company has found that none of the manufacturers have adopted in their calculations on existing gauges the legal units used in the manufacture of their lamps. They have also found that in employing many men in construction work some standard whose units of measurement are in themselves significant is almost imperative.

"Thus, in almost every detail of their system of installing large numbers of plants of greatly varied capacity, and in calculations for central stations, not only in this country but throughout the world, the problem of arriving at a standard based upon the principles of distribution, and a graduation of sizes embodying something beyond an arbitrary and meaningless scale, and capable of meeting other requirements, forced itself upon the attention of their engineering department.

"It is in order to avoid the difficulties heretofore experienced that a gauge has been worked out and adopted by the Edison Company which meets all requirements outlined by their experience. It is based upon the cross-section of the wire in circular mils., and the sizes indicate in convenient steps even thousands of this unit of measurement, from 3,000, the smallest found to be mechanically and electrically efficient in the equipment of buildings with Edison conductors, to 360,000, which represents a rod of copper six-tenths of an inch in diameter, such as may be used in the Edison underground system.

"The accompanying table gives the full number of sizes adopted, together with the other useful data required in calculation. Under the column headed "Diameter in Mils." are given the numbers whose squares appear in the column headed "Actual Circular Mils.," which correspond most nearly to the even thousands given in the second column.

"By this system of graduation, the relative conductivity of wires

TABLE OF DIMENSIONS, WEIGHT, AND RESISTANCE AT 50°C. OF PURE COPPER WIRE.

E.S.G. Gauge Number.	We give the nearest B.W.G. numbers for convenience of reference.	Circular Mils. in Even Thous.	Maximum Amperes. $A = \sqrt[4]{\left(\frac{C.M.}{10^4}\right)^3}$	Diameter in Mils = .001in. = *d*.	Weight. Sp. Gr. 8·889 I. Lbs. per Foot.	II. Llbs. per Ohm.	Length. III. Feet per lb.	IV. Feet per Ohm.	Resistance. Legal Ohms at 75° Fahr. V. Ohms per lb.	VI. Ohms per ft.
3	17—18	3000.	12.5	54.78	.0090837181	2.597068	110.0870793	285.9038	.3850405	.003497600
5	15—16	5000.	18.3	70.72	.0151392409	7.213802	66 0535101	476 4970	.1386225	.002098640
8	13—14	8000.	26.0	89.45	.0242203427	18.463613	41.2876061	762.3184	.0541602	.001311780
12	12	12000.	35.2	109.55	.0363282400	41.537931	27.5267946	1143.4061	.0240743	.000874578
15	11	15000.	41.6	122.48	.0454098377	64.901697	22 0216596	1429.2431	.0154078	.000699663
20	9—10	20000.	51.6	141.43	.0605484008	115.371827	16.5157078	1905.7189	.0086664	.000524745
25	8—9	25000.	61.0	158.12	.0756821055	180.27794	13.2131630	2382.0418	.0055470	.000419807
30	7—8	30000.	70.0	173.21	.0908166584	259.72226	11.0111957	2859.8526	.0038522	.000349840
35	6—7	35000.	78.6	187.09	.1059548264	353.34049	9.4380769	3334.8547	.0028301	.000299863
40	6	40000.	86.8	200.00	.1210820000	461.44010	8.2588659	3810.9720	.0021671	.000262400
45	5—6	45000.	94.9	212.14	.1362274802	584.09787	7.3406628	4287.6655	.0017120	.000233227
50	4—5	50000.	102.7	223.61	.1513568350	721.02630	6.6069034	4763.7514	.0013868	.000209914
55	4—5	55000.	110.3	234.53	.1665008296	872.54729	6.0059761	5240.4982	.0011467	.000190821
60	3—4	60000.	117.7	244.95	.1816245211	1038.25764	5.5058645	5716.5059	.00096315	.000174931
65	3—4	65000.	125.0	254.96	.1967721793	1218.5857	5 0820192	6192 8868	.00082057	.000161465
70	3—4	70000.	132.1	264 58	.2119012989	1413.2644	4.7191732	6669.4464	.00070758	.000149937
75	2—3	75000.	139.1	273.37	.2270432099	1622 4571	4.4044479	·7146.0276	.00061635	.000139938
80	2	80000.	146.0	282.85	.2421764790	1845.9518	4.1292176	7622 3367	.00054172	.000131193
85	1—2	85000.	152 8	291.55	.2573034954	2083 7594	3·8864608	8098.4491	.00047990	.000123480
90	1	90000.	159.5	300.00	.2724345000	2336.4054	3.6706071	8574.6870	.00042807	.000116622
95	1—0	95000.	166.1	308.23	.2875872249	2603.0461	3.4773124	9051.6047	.00038415	.000110477
100	1—0	100000.	172.6	316.23	.3027092769	2884.0822	3.3034996	9527·5645	.00034673	.000104960
110	1—0	110000.	185.4	331.67	.3329906016	3489.9577	3.0030877	10480.6483	.00028556	.000095410
120	0	120000.	198.0	346.42	.3632666336	4153.4329	2.7527[illegible]89	11433.5654	.00024070	.000084460
130	...	130000.	210.2	360.56	.3935271358	4874.2259	2.5411208	12385.9938	.00020514	.000080730
140	...	140000.	222.2	374.17	.4237966529	5652.8989	2.3596222	13338.7058	.00017690	.000074970
150	...	150000.	234.0	387.30	.4540614049	6484.5728	2.2023452	14291.2678	.00015409	.000069997
160	...	160000.	245.6	400.00	.4843280000	7383 0425	2.0647164	15243.8880	.00013544	.000065600
170	...	170000.	257.0	412.32	.5146220577	8335.5249	1.9431736	16197.3720	.00011995	.000061735
180	...	180000.	268.3	424.27	.5448842348	9344.6859	1.8352522	17149.8535	.00010701	.000058309
190	...	190000.	279.4	435.89	.5751397788	10411.2406	1.7387097	18102.1258	.00009604	.000055242
200	...	200000.	290.4	447.22	.6054273401	11536 6814	1.6517233	19055.4057	.00008667	.000052478
220	...	220000.	312 0	469.05	.6659749213	13959.5666	1 5015580	20961.0990	.00007163	.000047707
240	...	240000.	333.0	489.90	.7264980844	16612.1144	1.3764661	22866.0134	.00006019	.000043733
260	...	260000.	353.5	509.91	.7870578463	19496.9968	1.2705546	24772.1000	.00005129	.000040368
280	...	280000.	373.7	529.16	.8476051956	22612.2329	1.1797944	26677·7858	.00004422	.000037484
300	...	300000.	393.6	547.73	.9081396792	25957.4640	1.1011502	28583.0667	.00003852	.000034986
320	...	320000.	413.1	565.69	.9686716683	29533.6961	1.0323418	30488.2691	.00003386	.000032799
340	...	340000.	432 3	583.10	1.0292139817	33340.1808	·9716143	32393.7964	.00002999	.000030870
360	...	360000.	451.3	600.00	1.0897380000	37376.6518	·9176517	34298.7480	.00002675	.000029155

1 Mil. Foot=9,718 B. A. Units at 0° C. [DR. MATTHIESSEN.]

is accurately expressed by their numbers, two strands of No. 20 being required to equal a No. 40, and a No. 200 being capable of conveying with a given percentage of loss in a given distance twice the volume of current of No. 100.

"This direct reversal of the former empirical numeration of sizes, by which the highest gauge number has represented the smallest wire, would seem to commend the new gauge to all who use conductors for incandescent lighting, if it could show no other feature of progress.

"The figures of the table thus formulated are based upon the universally accepted standard of resistance reached by Dr. Matthiessen's experiments, viz., 9·718 B. A. units per mil. foot of pure copper wire at 0 degree Centigrade.

"The Edison Company both here and in Europe have for some time used the legal standards of E.M.F. and resistance, and the apparatus at the factories of the Edison Lamp Companies throughout the world, by which all other devices are calibrated, was secured from the Electrical Standardising Committee of the British Association at the Cavendish Laboratory. Hence this gauge is based upon the reduction of the 9·718 B. A. units to 10·496 legal ohms per mil. foot at 75 deg. Fahrenheit.

"It is not possible to secure commercially uniform standards of purity in copper conductors. An impurity of 2 or 3 per cent. does not make itself known in weight, length, or other apparent details. A correspondence with all the leading wire manufacturers of the country has shown the Edison Company that a wire of 97 per cent. comes within the guarantee of all these firms, and in the actual calculation of conductors a resistance of 10·82 legal ohms per mil. foot can be adopted as a safe average.

"The weights of copper in the Edison gauge tabulation are based upon 555 pounds to the cubic foot, which corresponds closely to the standard specific gravity 8·889. On this basis the weight of a mil. foot is 0·00000302705 pound.

"We may sum up, then, the advantages which this gauge offers to electric light engineers in five points :—

"1. The sectional area as the basis of graduation.

"2. An increase in the number of sizes by which close approximation may be made to any cross-section required to secure a specific fall in potential.

"3. A graduated system of numbers expressing definite relative values.

"4. A new feature for numbering the wire, as No. 3, No. 5, No. 8, No. 12, &c., each number meaning so many thousand circular mils. sectional area, thus making the number and area of the wire easily remembered by the ordinary workman.

"5. The use of the legal ohm, thus basing American calculations upon European standards now universally adopted.

"The safe carrying capacity of the various sizes has been deducted from actual experiment in the Edison laboratory nearly two years ago, and upon them many subsequent tables have been based.

"These tables and statistics will be used in the future work of the Edison Company, and all determinations and recommendations from their engineering department will be given the prefix 'E. S. G.,' indicating with the number which follows the thousands of circular mils. required, as, for example, 'E. S. G. 200,' signifying 200,000 circular mils., Edison gauge."

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THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At an ordinary meeting of this Society, held at the Institute of Civil Engineers, Great George-street, Westminster, on Thursday, 10th inst., the president, Sir CHARLES BRIGHT, C.E., announced that in consequence of the death of Sir Francis Bolton, one of the Society's vice-presidents, the council had elected Prof. Ayrton to the vacancy, and had appointed Prof. Rücker in the place thus created on the council. A resolution expressing the deep regret of the Society for the loss sustained by the event referred to, and a vote of condolence to Lady Bolton and family were proposed and carried unanimously. The president then referred in feeling terms to the late Colonel Sir John Bateman-Champain, a past-president of the Society, the announcement of whose premature decease on the 1st of this month had filled them with such surprise and sorrow. Besides being a gallant officer who had served his country in the profession to which he more strictly belonged, he had rendered valuable service to the telegraph world in the East; and on this point he, Sir Charles Bright, could bear his personal testimony, having on many occasions had to work in conjunction with Col. Bateman-Champain when our Indian dependency and the adjoining countries were being first connected with Europe by cables and land wires. The president furnished some further details of Col. Bateman-Champain's career, corresponding in the main with the obituary notice which appeared in *The Electrician* on 4th inst. Col. Webber, R.E., followed, paying a touching tribute to the memory of the gallant officer, and the meeting then passed a resolution expressing its sense of the loss the Society had sustained in the death of one of its most eminent and useful past-presidents.

On the resumption of the adjourned discussion upon Prof. Silvanus Thompson's paper relating to "Telephonic Investigations," Mr. W. H. PREECE, F.R.S., concluded the brief remarks he had been able to make at the last meeting. Speaking now at some length he adduced a considerable amount of evidence, both of a scientific and practical kind, in confirmation of his expressed opinion that the remedy for the evils which such investigations as those of Prof. Thompson were designed to correct was not at all in new forms of apparatus, but in improving the condition of the lines; and that it could be easily proved that the evils inherent to bad lines, or lines ill adapted to telephonic working, could not be made workable merely by the use of stronger currents and less sensitive receivers. Telephony, like telegraphy, was governed by well-defined laws, and the circumscribed limits of the law in relation to speed of working, which applies equally to both, could not be evaded by the employment of new apparatus, however ingenious. This electrical law was the one drawn up by Sir W. Thomson, and published by the Board of Trade in 1860 or 1861. It was the outcome of a vast number of experiments in which he (Mr. Preece) himself had assisted both Mr. Latimer Clark and Prof. Faraday. What was true for cables had been proved to be true for land lines, and had been demonstrated beyond all dispute by recent experience with fast-speed Wheatstone apparatus and the Delany multiplex system. It amounted to this, that the number of signals capable of being separately signalled in a given time depended wholly upon the capacity and resistance of the line, and was not in the least affected by the E.M.F. employed at the sending end. Knowing the resistance and capacity of a given wire, we can calculate to a nicety the rate at which telegraph signals can be transmitted upon it to varying distances; and similarly, as we know pretty nearly the number of vibrations required to be signalled in telephony when speaking has to be clearly reproduced, we can say beforehand, and without regard to the battery power we intend to employ, what is the distance to which we can speak satisfactorily on a particular wire, the character of which is known to us. Of course the result may vary with the instruments used; some are good and some are not so good; but a novel form of instrument will not affect the general result, and certainly not a new departure altering the current strength. As to the "disturbances," Prof. Thompson's design was to drown them by a greater disturbance. The notion was an old one, and dated from the time when these disturbances first became inconvenient; but nobody had succeeded in eliminating them by making the receiver weak and the transmitter strong. It cannot be done on short lengths at all, though on long circuits the device may prove more successful, the disproportion between the disturbing current and the main current in the case of telephone and telegraph lines side by side being less when both lines are of considerable length. On the shorter telephone wires the disturbances are greatest, and Mr. Preece was understood to say that these, which are by far the most numerous, cannot be protected from the effects of neighbouring currents by any device of the kind here suggested. Incidentally Mr. Preece informed the meeting that the speed of Post Office working to Ireland had lately been increased from 170 words a minute to 420 by the substitution of copper for iron land wires. This speed of working corresponded, upon the average, to 190 reversals, or 380 distinct currents *per second*, which approaches the requirements of telephonic speaking, and it was a fact that on a copper wire, even when underground, speaking was a vast deal better than on any iron wire overhead. In fact, the difficulties of underground telephonic communication had undoubtedly been greatly exaggerated. He concurred in what Prof. Thompson had said in regard to the heat theory in explanation of the microphone; he had only one complaint to make about it, namely, that the lecturer had omitted to state that the theory was his, Mr. Preece's.

Prof. D. E. HUGHES: Prof. Thompson has brought before us in his remarkable paper a series of most interesting experiments which offer a wide field for discussion. I cannot quite agree with Prof. Thompson in his general classification of transmitters and receivers, nor does he sufficiently indicate those which are merely of scientific interest, but whose results are too feeble for any use, from those which give results of such high value as to be of vast practical importance. The electric transmission of speech was at first considered impossible, but since the great advances made in telephony from 1862 to the year 1878, successive experimenters and innumerable researches have shown that almost all changes in matter caused by vibration, including the effects caused by heat and light, can be used as transmitters and receivers, and I congratulate Prof. Thompson on having been able to add a new effect—viz., that of the layer between a drop of water and a heated metallic surface, the water then being in the well-known spheroidal state. This effect, however, must be excessively feeble, and whilst of no practical value it is certainly most interesting from a scientific point of view. Prof. Thompson has also given us a list of the materials he has experimented with for microphonic contacts. They include a far greater variety than I have been able to try, and I hope that the copper selenium composition he has mentioned as being superior to carbon for a short time can be so perfected as to render it durable and practical in every respect. As regards the best arrangement of the microphone, whether in single, parallel, or in series, I believe it entirely depends upon the question of the use for which it is required, and all those who saw my numerous microphonic instruments from Oct., 1877, to May, 1878, will remember that in some I had them in series, as, for instance, in the glass tube transmitter, which contained from four to six pieces of hard carbon superposed, thus having six joints or loose contacts in series. And very often I joined the pencil microphones in parallel, as for instance at Mr. Preece's lecture in this hall, when the transmitter which was used down stairs to convey the speech and music to the hall had two microphones joined in parallel. I saw then that there was nothing new, or any new law that was demonstrated by the joining up of microphones in any conceivable way, for they obeyed in this respect the well-known laws which were known and followed in telegraphy, viz, if we wish to obtain the greatest possible variation on a line of great resistance, then the microphones should be arranged in series, as we arrange the cells of a telegraph battery, for in this case the internal resistance of the cells is far less than the resistance of the line, and this is equally so with the internal resistance of loose contacts of microphones in series; but if we wish in telegraphy to work on a short line of low resistance, then the resistance of the battery and electro-magnet must be reduced. And so it is with the microphone, for when we employ it on the short, thick wire of an induction coil, we should employ a battery of large surface or low resistance, and the total resistances of the microphones should be reduced by joining them in parallel. A great deal of attention has been paid to the best arrangement of microphones, but too little attention has been given to the most suitable induction coil. For it is evident that each particular transmitter requires that the battery and the primary wire of the coil should be in proportion to the internal resistance of the transmitter. The secondary wire should also be proportioned to the resistance of the line upon which it is used, and from some researches that I have made on this subject, it is evident to me that great progress will be made by improved induction coils for telephonic purposes, and Prof. Thompson has shown in his paper that he is fully aware of the importance of this question.

I do not quite agree with Prof. Thompson in his theoretical explanation of his valve telephone. He considers that the ball or valve does not vibrate itself, but follows or rides upon the vibrations of the air waves. I agree that the ball does not vibrate of itself to any great extent, but I do not believe that it follows or rides upon the vibrations of the air waves. In my mind the true explanation will be found in the experimental fact that the sonorous aerial vibrations impinge on the sides of the tube, putting this into an intense mechanical vibration, and these vibrations are conveyed to the supports of the ball or valve, whose loose contact produces the microphonic effect. The tube does not become a diaphragm when thus employed, but it is by its solid nature twelve or fourteen times a better conductor of sound than air, and, consequently, the vibrations are conveyed through a tube, or it may be a solid rod, with far greater velocity and force than through the air itself. There is no difference in the mode of propagation of sounds in solids or the air except their greater velocity through solids, and if a solid body, no matter what form or how used, is a legal diaphragm, then the air itself is an English legal diaphragm. To prove that it is not the ball, but the tube, which vibrates, let us close the tube below the ball, allowing the air to escape by a side aperture in the tube; we shall then find that it works more perfectly than before Or let us take away the ball, and attach several pencil microphones to the exterior of the tube; we shall then have a very perfect transmitter, fully equal to those disposed on sounding boards.

Prof. Thompson has shown us his arrangement of 108 microphones attached to a rod in connection with a diaphragm, the microphone being contained in a box, the upper portion of which sustains the diaphragm. I do not think this to be a hopeful arrangement. We do not need the to-and-fro motion of the diaphragm; let us, therefore, attach these microphones all round the interior of the box, and speak simply in the box, and we shall have all the effects we desire. No doubt we should then have, in addition to our ordinary voice, the hollow tones of the box; let us, therefore, fill the box with pure water, so as to entirely submerge the microphones. We then find that the hollow tone of the box has in a great measure disappeared, whilst the microphones seem to work with increased power, as every portion of the fluid, being in a state of tremor, conveys to the microphones the vibrations

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transmitted by the voice to the water and box. We all know the remarkable power which water has of conveying sound, and to test this in 1878 I took a microphone to one of our public baths. The room appeared quite silent, but on submerging the microphone in the bath a prefect uproar of sounds was heard, doors shutting, flowing of water in other rooms, steps, voices, all mixed in one terrific noise. The remarkable power of the microphone to detect the flowing ot water or any leakage in waterpipes seems to have received a practical application, for *The Electrician* of January 28th of this year contains the following paragraph :—

"At the recent Congress of Gas and Water Engineers, held at Eisenach, in Germany, it was stated that many German water companies had adopted the microphone as a part of the regular equipment of their turncocks, in order to enable them to detect the presence and estimate the importance of any leakage. The microphone is fixed upon a plate which can readily be attached to a stop cock. It is said that the presence of a leakage at the rate of only a few drops a minute can be readily detected by this means."

This paragraph entirely agrees with the experiment that I made with submerged microphones in the bath, and I believe from this and other experiments that there is a field of research open for microphonic transmitters submerged in a fluid contained in receptacles of different forms. In the portion of Prof. Thompson's paper upon the telephone receivers there are many interesting and valuable points. He very properly considers that it is not the province of an inventor of telephone instruments to cure the lines of their numerous defects, but to construct instruments which will work satisfactorily through the defects which at present exist. Long or short distance telephony, like telegraphy, does not depend upon the mere distance or resistance of the line, for we have in addition to consider the static and self-induction, both causing a retardation and flattening out of the extremely rapid waves; and we have also leakage from wire to wire, and electro-magnetic or mutual induction of one wire upon another, causing induced currents which interfere greatly with those we wish alone to receive. These defects can be greatly diminished by a proper construction of lines, but taking these defects as they undoubtedly exist at the the present time, I do not believe that we shall arrive at better results by the use of less sensitive receiving instruments, or rather by instruments having greater inertia in their armatures, and consequently less capacity for rapid currents. Prof. Thompson has shown that a polarised magnet is more sensitive to rapid alterations of currents than a simple soft iron electro-magnet, and this has long been known in telegraphy, for of the innumerable forms of relays that have been tried for rapid telegraphy there are hardly any which have survived which are not more or less polarised by a permanent magnet. We all know the Siemens form and the Post Office form of polarised relay, but the electro-magnet which is the most highly polarised of all is the one invented by myself and patented in 1885, and still in use throughout Europe in my printing telegraph instrument. In this electro-magnet the soft iron cores of the electro-magnet are simply the prolongation of the poles of a powerful compound permanent magnet. This form of electro-magnet I found advantageous, first, because it allowed me to have a powerful retaining magnetic force acting on the armature, and secondly, because I found that an electro-magnet when highly polarised was more sensitive to rapid feeble currents than when not polarised. For this reason, the permanent magnet is made to polarise the electro-magnet with far greater power than that needed for the mere holding of the armature, in fact, it is so strong that I have in practice to reduce its retaining effects on the armature by separating it from the poles by a piece of paper. Now, this arrangement is well known as the Hughes magnet, but there is another which is not quite so well known in England. In 1863, finding it necessary to use a relay which should be equally rapid as the instrument itself, I constructed several relays for the French telegraph lines in which my polarisd magnet was used, acting at a distance upon a soft iron armature similar to other relays, the only difference being the replacing of the old soft iron electro-magnet by the one used in my instrument. This acted extremely well and it is in use to this day. Mr. Elsasser has made in Berlin a particular disposition of relay with the same electro-magnet, which I believe has great advantages for subterranean lines.

Let us now look at the most powerful and successful telephone receivers yet made—as in the box form of the Bell—and in the similar arrangement of the Gower Bell. The polarised magnet there used is identically the same as mine, and this is a proof that my old form of polarised electro-magnet still remains one of the best for purposes where extremely rapid currents are used. To Graham Bell and his associates belongs the credit of having produced the best telephone receiver, by a combination for telephonic purposes of an iron diaphragm with a polarised electro-magnet, The greatest difficulty which is at present encountered on our busy telephonic lines is that due to the mutual induction of one line upon the other, and this would be fatal to sensitive telegraph relays if we had not the power of so adjusting the armature between its contacts that it will not respond to currents less than those intended to be received. In a telephone, however, the diaphragm does not play between any fixed limits, and a very sensitive telephone becomes influenced not only by the desired currents, but also by the extraneous currents. It is not possible to work on a telegraph or telephone line if the induced currents have an equal or greater power than those we wish to receive; very fortunately, as a rule, they are far less, and we have then this adjustment of a sensitive telephone, which so far seems the best we can obtain, and that is to reduce the sensitiveness of the instrument by removing the electro-magnet gradually away from the diaphragm until we can either no longer hear the induced currents, or that their effect is so small as to be hardly appreciable. Unfortunately in so doing we also reduce the sensitiveness of the receiver for its own currents, and the sounds received are greatly enfeebled. We can also arrive at the same results by using coarser or less wire on the electro-magnet, using a switch to cut out more or less layers as desired. We cannot, however, by either of these or any known method preserve the loud tones produced by the currents we desire and reject those which are not desired; nor do I believe that the question can be resolved by constructing telephones of less sensitiveness without any other corresponding advantage. In all rapid relays we have to make the armature small and light, in order to have as little inertia as possible. Prof. Bell, in making a thin iron diaphragm the armature of the electro-magnet, reduced the inertia as far as possible, whilst from its large surface the lines of magnetic force are not confined to any single part. This freedom from inertia allows the diaphragm to respond to an almost infinite rapidity of currents with a perfect sharpness of definition. It is well known that all telegraph relays will work as a receiving telephone by attaching a thread from the armature to a diaphragm of parchment or any suitable material. I believe this was first shown by Breguet in 1877, who attached an ordinary string telephone to the armature of an ordinary polarised relay. It was also shown by Mr. W. H. Preece about the same time, who, I believe, patented this method. But one of the earliest and most successful attempts in this direction was made the same year at the Newfoundland station of the Atlantic Submarine Cable Company. They attached an ordinary parchment diaphragm by a thread to the coil of Sir W. Thomson's siphon recorders and as we know the exceeding sensitiveness and rapidity of this coil, we know that the result must have been, as stated, extremely good. Prof. Thompson has brought before us some very interesting and novel form of telephone receivers, and I have no doubt that he has by comparative experiments been able to test their respective merits, but I cannot agree with him when he believes that we must follow the lines of a dynamo in order to improve our telephone receivers. The two objects are totally different. Though they are both converters of electric energy into mechanical motion, the motion in both is entirely different; the one acquires a continuous rotary motion where the inertia of the armature may be neglected, whilst the other requires a reciprocating motion of great rapidity through an exceedingly small space, requiring also that mechanical inertia must be avoided as far as possible. We have rather to follow the lines of known telegraphic applications, and from these we learn that telegraph relays are far more efficient transformers of feeble currents than any dynamo possible.

There is one point in Prof. Thompson's paper with which I thoroughly agree, and that is, if we are to work with more perfection through our present defective lines, we must look for improvement in having more powerful transmitted currents through a better arrangement of the microphones, and, above all, in the use of a more perfect and suitable induction coils than those in use at present, for we can then adjust or construct our receiving telephones beyond the range of disturbances, and receive with perfect clearness, due entirely to the more powerful currents sent by the transmitter. There are many other points of very great interest contained in Prof. Thompson's valuable paper, such as the effects of heat on microphonic contacts, and his theory of molecular bombardment, but as I have already taken up more than my share of time I must leave these to others.

In conclusion, I must express my thanks to Prof. Thompson for having brought before our society a paper so full of interesting experiments, and one so well worthy of discussion.

Mr. MOYNIHAN read some notes upon the paper, asking for particulars as to the tests to which Prof. Thompson's latest devices had been put, and remarking that, although he appeared to have invented a new telephone at the rate of about one every week for the last eight years, none of them were intended so much to get over difficulties in telephonic working as to circumvent what he regarded as a galling monopoly.

Mr. STROH being invited to address the meeting, reverted to some observations he had made at the time the microphone was under discussion. He was much interested in the theory that heat played an important part in the action of that remarkable invention, and the experiments he then made to test the point were perhaps worth recounting again now. He had placed a diminutive microphone so that the surface of contact could be examined by a microscope, and had observed what takes place when the current was passing between them. The conclusions he had arrived at were that the heat supplied by the current when a carbon is used for the first time burns off the minute points at which alone contact is at first made, and it is then reduced to exactly the condition most suitable for microphonic transmission. Secondly, that when a steady current is flowing through the circuit there is a tendency to repulsion between the two carbons, which, being controlled by the spring attached to one of them, causes vibration like that of an electric bell, and the pitch of which rises as you tighten the spring, until it is lost to hearing, although it still goes on. He had tried to ascertain which of the two carbons became hottest under the current by placing between the contact points a tiny drop of oil; but although the eddying currents in the drop were generally observed in definite directions, they did not always alter with a reversal of the electric current, and therefore no positive conclusion could be arrived at on this evidence. It was noticeable that the tone in which a given sound was reproduced could be altered by slightly jarring the microphone, the ticking of the same watch being, for example, reproduced often in quite a different note if the carbons were at all disturbed, a fact which showed that fresh points of fusion were being brought into play. He thought that in their passive condition, that is, in their condition when a steady current was flowing, they were in constant vibration, and that the active condition brought about by external vibration, such as the ticking of a watch or the human voice, caused the microphone to vibrate in unison with it, the normal vibrations then assuming the character of the abnormal vibrations. The current itself varying in like manner actuated the diaphragm at the receiving instrument, so that identical sounds were reproduced there.

The hour being late the discussion was again adjourned till the 24th inst.

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DISCUSSION IN THE FRENCH CHAMBER ON TELEGRAPHS.

In our issue of July 16 last year we referred to a project which was before the French Government to subsidise certain cable schemes. The adjourned discussion on the project has lately been occupying the attention of the French Chamber of Deputies, and has given rise to a most remarkable anti-English feeling from the official clique supporting the scheme. We can do no more than give a very brief abstract of the discussion. In the early part M. Roulleaux-Dugage protested that the question under discussion was a purely business question, and involved no Ministerial crisis. As his text he took the map of the world, and pointed out the various telegraph cables existing, winding up almost each sentence with "Again an English company," or "Always England, gentlemen." He pointed out certain disadvantages which arise to any nation from not having control of cables to every one of their own dependencies. It was pointed out that England had several very large factories engaged in the work of the manufacture of cables, that it had a fine fleet of some twenty ships of from 1,500 to 5,000 tons burden. In France they had neither factories nor ships capable of carrying out the necessary work connected with cable manufacture and cable laying. He referred also to the technical schools which existed in England, naming the City and Guilds Institution (which we in England do not recognise as a telegraph school), and which, moreover, is incorrectly described as being subsidised by the State. The general tenor of the speech must, in fact, be said to be one long diatribe against England. M. Granet, the Minister of Posts and Telegraphs, followed, and stated that he was perfectly in accord with M. Roulleaux-Dugage as to the institution of telegraph schools. M. Felix Faure pointed out that the time of transmission from Marseilles to Paris was eighty-six minutes, whereas for messages transmitted direct to London it was about eighteen minutes. He also pointed out that throughout the internal telegraph system of France similar delays existed. M. Granet promised that this state of things should be altered.

The following gives the arguments brought forward by the supporters of the Antilles Cable Company's scheme to induce the Chamber to assent to the proposal:—

The submarine cable industry does not exist in France. The factories belonging to private industry which might be put into a position to manufacture submarine cables are not accessible to the ships necessary for effecting their submersion. France, then, is principally dependent upon England for submarine telegraphic communications. It is, in fact, from England [*by English companies as private concerns and nearly all without subsidies.*—ED. E.] almost exclusively that the whole of the cables submerged in the entire world have been sent out, and during the war of 1870 it was England who supplied to France the line laid on the eve of the investment of the capital, between Paris and Rouen, in the same manner as those submerged in the Channel and in the ocean, for the establishment of the communications indispensable for military operations. It was still to England that they had to address themselves, notwithstanding the repugnance of the Chamber, for the establishment of a submarine line to Tonkin. It is out of the question that a country like France should any longer remain under the disability of being unable to manufacture its own cables, and be in consequence dependent upon the foreigner for this important industry. The establishment which the State possesses at Seyne cannot be taken into account. This establishment is only a repairing shop for the Mediterranean cables, it cannot manufacture the conductor of cables, and in any case it is inaccessible to ships of heavy tonnage, such as the vessels employed in laying a line of any importance ought to be. All the telegraph lines which connect France with its colonies, with the sole exception of three cables belonging to and worked by the French Government, connecting Marseilles with Algiers, are in the hands of English Companies. The same is the case with regard to the telegraphic lines which connect France with the countries beyond sea. Now, on the one hand, the theory of the right of neutrals professed and admitted in England is that in time of war neutrals have the right of stopping the correspondence of belligerents; and, on the other hand, the Companies whose cables land on English territory are bound by agreement to place on the first requisition their telegraph stations in the hands of the military authorities. It follows from this that France [*But France and every nation which gives landing rights reserve this right of control. Then what is England's position at Marseilles, Paris, Cochin China, &c.?*—ED. E.], in the least conflict she may have, will be threatened with having her telegraphic communications with her colonies and with most of the countries beyond sea, placed from day to day at the mercy of the English Government. In fact the English companies, controlling all the time both the means of manufacturing cables and the working of the submarine telegraphic lines, charge an exaggerated [*What with the T. C. and M. Co., the Silvertown Company, Siemens, and Henleys' competing one against another; the idea is preposterous.*—ED. E.] price for the cables which must be ordered from them, and maintain tariffs [*Are not the tariffs fixed and discussed at the Telegraph Conferences, at which the cable companies have not even a vote?*—ED. E.] for the transmission of messages at equally exaggerated rates. The adoption of the project submitted to the Chamber for the Antilles' cable should provide a powerful remedy for this doubly unfavourable state of things.

The said projected system of the Antilles is composed of a cable starting from Para (Brazil) touching

At Cayenne........................	French Guiana.
,, Paramaribo	Dutch Guiana.
,, Martinique........................	French Possession.
,, Guadaloupe	—
,, Mona	Spanish Possession.
,, Puerto-Plata	Dominican Republic,

and terminating at New York, United States of America, where it will join the direct French cable, landing at Brest. Branches will go to connect Curaçao, Caracas, and Panama. This cable will give France the power of communicating with its colonies at the Antilles and with the whole of America without using any of the cables worked by the English companies, and without touching at a single point of English territory; it is a release from the dangers and inconveniences set forth above resulting from the present situation, and this for an important part of the relations of France with the world.

From the general point of view this project fills up the gap [*A cable was laid and failed, but the business outlook was not sufficiently good to induce another attempt.*—ED. E.] which the English monopoly has left in order not to compete with itself, the effect of which is that telegraphic communication between the two Americas can only be effected *viâ* Europe. As an immediate effect upon the communication between France and its colonies, the actual charges will be reduced by a very large proportion. In short, in the contract submitted to the approbation of the Chamber, the Concessionaire [*The concession has been refused to Count d'Oksza.*—ED. E.] undertakes, in view of the approaching establishment of a direct cable from Cuba to Cadiz, to prolong this cable at the choice of the French Government, either to Marseilles *viâ* Oran, or to Brest *viâ* Lisbon. This cable would constitute for France a second way of communication with America independent of every English element—the first being given by the Pouyer-Quertier cable from Brest to New York. The ministerial project stipulates that the Company to be constituted for the construction and working of this Antilles system shall be French [*Yet the promoter is not a Frenchman, and is, according to M. Faure, unknown to the majority of Frenchmen,* v. *M. Faure's speech.*—ED. E.], shall manufacture the cable in France, and shall employ a French staff. For this purpose a powerful factory will be a once created in a French port. In this manner, France may look forward to the moment when she shall be liberated from the foreign monopoly to which she now submits, not only for her telegraphic communications with the countries beyond sea, but even for the construction and supplying of the cables which she finds necessary. This is a truly important double result, and one which would fully justify consent to a sacrifice borne by the State; but it is easy to show that in the present case this sacrifice, consisting of giving to the enterprise a guarantee of a revenue of 1,000,000fr. (£40,000) is only apparent, for in all probability this guarantee will never have to be exercised.

[*An estimate of probable receipts was given, but, like all such estimates, when analysed it comes to no tangible result. The receipts of four companies are mentioned, one of which pays no dividend, a second has paid on an average for thirteen years one half per cent., and these two companies' receipts come to more than half the total estimated.*—ED. E.]

It is fully proved, then, that the guarantee given by the French Government will not require to be exercised. Under these conditions, is it necessary? Without doubt it is, for in France the public is not, as in England, familiarised with enterprises similar to the one in question, and it is to be feared that shares offered without guarantee could only be issued at a very low figure; the undertaking would thus find itself hampered from the beginning, and with a nominal capital out of all proportion to that paid up. On the other hand, shares guaranteed by the Government would certainly be placed at a figure nearly approaching that at which the railway companies are able to borrow. In reality, the assistance demanded from the State is limited to a patronage [v. *M. Faure's speech.*—ED. E.] which will enable the Company to profit by the credit which the State enjoys. In exchange for this purely moral [v. *M. Faure's speech.*—ED. E.] assistance, the new company will provide France with two creations of capital importance, consisting of—*First*, an independent French system of submarine telegraphic communications with the New World; *Second*, the establishment of a factory for the manufacture of submarine cables sufficiently powerful to make France independent for ever of the foreign monopoly.

The discussion on the 12th February is extremely interesting. The President said: "The order of the day calls for the first debate on the project of law involving the approval of an agreement relative to the establishment of submarine telegraphic cables intended to connect the French Colonies of the Antilles and the French Guiana. The general discussion is open."

M. LUCIEN DE LA FERRIÈRE opposed the project. Among other things he pointed out that this was an "enterprise which up to the present has only been worked in anticipation, and which has only its name; it is presented to you under the title of the 'French Telegraph Company of the Antilles.'" Continuing, he pointed out that so far as regards the Antilles, there existed an agreement with the West India and Panama Telegraph Company which would last for another ten years. So far as concerns Guadaloupe, the agreement expires in 1895, but the colonial council of Martinique, on the other side, prolonged it to 1900. In 1874, the agreement with the Western Brazilian Company was made for fifteen years, and an increased subsidy was to be paid for that company extending its system to Surinam. The cables which were laid were soon broken, and M. de la Ferrière stated that the loss to the company was not less than £300,000. From that time telegraphic communication had been interrupted with the Cayenne Colony. The same company, in 1878, submitted a new proposition and still more recently another, which offers to establish the interrupted communication for an annual sum of £2,000. He ridiculed the company with which the Government proposed to treat, saying, "Have they a defined and established constitution? Have they a legal form adjusted? Have they any disposable capital? Do they offer assured guarantees? It will suffice, gentlemen, to read the preamble of the agreement to see whom we find ourselves in presence of. 'Between the Minister of the Posts and Telegraphs, on the one part, and the Count d'Oksza, in the name and for the account of a company *to be constituted*, under the title of "*The Telegraph Company of the Antilles.*"' I read you, gentlemen, 'the company to be constituted.' I

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quite understand that the Minister of Posts and Telegraphs will not be slow to point out that this formula is not exceptional, and that you can find the same preamble in many similar agreements. I admit that I should be very incompletely satisfied with this reply. It rests, in fact, with the Government to see that any Company should present itself from its origin with assured guarantees. He might insist that the future of the Antilles Company should not exclusively depend upon the credit which would be given to it by this signature of France. Well, gentlemen, what would be the capital of this Company? It is to this that I particularly call your attention. Capital, up to the present, it has none, and I must add that it does not need it, because it is the French State which will give it to them. In effect, if you will just refer back to Article 12, which I have examined from two points of view, you will see the following:—"With the object of facilitating the establishment of the system of cables which is the subject of the present contract, the French Government authorised a company to issue debentures, the annual charge of which, comprising interest and sinking fund in twenty-five years, shall not exceed the sum of £40,000 per annum. These debentures will have the privilege of the first charge on the system of the company specified in the present contract. The interest and sinking fund will be, moreover, guaranteed by the French Government. But, before having recourse to this guarantee, the company undertakes to charge before any deduction, and pay to the full amount the receipts in respect of the traffic for the payment of interest and the sinking fund of these debentures." I was right, then, gentlemen, in saying that, according to this paragraph, the finances of the State would be burdened during 25 years at the rate of £40,000 per annum for the payment of the interest and for the sinking fund of the debentures. You will see that this is a question of really considerable outgoings, and one to which we cannot too much awaken the attention of the Chamber. And under what form, gentlemen, are we going to burden the finances of the State?

Another fact the Chamber should know which will militate considerably against any saving in official telegrams. In consideration of £2,000, the West India and Panama Company has undertaken the service of our two colonies with the Antilles. I read in the treaty come to on this head, Article 9, which it is very necessary that the Chamber should know:—"In consideration of this subsidy, the Company undertakes to publish daily, at the telegraph stations between the two towns of Basse Terre and Pointe-à-Pitre without there being any payment; therefore, a telegram making known the general, political, and commercial news of Europe and the United States, as well as the current prices of the markets, particularly of the four large ports of commerce of France, and, if needs be, the important events which may have an interest for the Antilles, according to the judgment of the company, who will consider the subjects to be included in this list publication." So you see, in what is summed up, the necessity of transmission of official telegrams. This article stipulates that the company is bound to send, gratuitously, messages constituting a sort of daily bulletin, exception being made, it is understood, of official despatches, properly so-called, and you have stipulated and put under charge of the company to send, at your will, all political and commercial news, the price of goods, and so it results that the number of telegrams has become extremely limited——

M. Bizarelli, the chief authority in support of this claim, complained that M. de la Ferrière was not justified in the criticism he had made. The desire was to improve telegraphic relations with the French colonies, and the advantages of the new scheme, he thought, were considerable. At present the messages went through the lines of the various companies all foreign with foreign staffs. [*We understand that most of the English companies adopt the system of employing natives of the country in which the station is situated, so that this statement about foreign staffs is hardly correct.* Ed. E.] M. Bizarelli went on to point out that there would be a reduction in tariffs, and he hoped altogether that they would economise £4,000 a year.

This statement was immediately challenged, when he said:—"We are spending to-day £2,400," and went on to state that the necessities of the service demanded increased communication.

The question of existing agreement was then touched upon, and it was pointed out that if the new scheme was adopted these subsidies would not be renewed at the expiration of the various agreements, and that a certain saving would then take place.

M. de la Ferrière had pointed out that Count d'Oksza had been refused the concession to establish a line between Cuba and Spain. This line had been made much of, but M. Bizarelli now said that although Count d'Oksza had been refused, it was no reason why some one else should not ultimately obtain, but he said "obtained or not matters little." Stress was laid upon the fact that the cables employed were to be of French manufacture, and he admitted that the existing factories "are insufficient, and that it would be necessary to establish new ones. The Chamber might be certain that they would be established for the use of the company being promoted."

Quotations from letters were made to show that not only the members but the country advocated the carrying out of the project submitted by the Minister of Posts and Telegraphs, "When," said M. Bizarelli, "we have in France cable factories we shall no longer be under obligation to foreigners. In return for these advantages it is evident that the company must ask something from the State, and before seeing what the company asks we should consider the cost of the work."

The length of line projected is 650 miles from Para to Guiana, 760 miles from Guiana to Martinique, 110 miles from Martinique to Guadaloupe, 500 miles from Guadaloupe to San Domingo, 160 miles between San Domingo and New York, with slack, making about 4,300 miles. To this must be added a line from Hayti to Curaçoa and Venezuela, another 1,000 miles. The cost per mile was given at £160, and there would be the cost of land lines, ships, and other incidental expenses, the whole estimate coming to one million eighty thousand pounds. The capital of the proposed company was £480,000, with a debenture capital of £600,000. The guaranteed interest asked for being at the rate of 6·6 per cent. on the debenture capital.

The subsidy granted with regard to the Tonkin cable was 331fr. per mile, and was spoken of as 8 per cent., and the proposed subsidy came to 273fr. per mile. [*We think that these figures must be somewhat incorrect.*—Ed. E.]

An estimate was made as to the business obtainable. This estimate was founded upon the returns of existing lines, and the speaker arrived at a total estimated income of £127,600 by one calculation, and £80,000 by another calculation, so that it might be said, "the guarantee of interest will not become operative."

Again and again this statement was made that there need be no fear of the guaranteed interest being required, and it was on this consideration, said the speaker, that the committee decided to give their support to the project. Certain sentences are especially interesting to English companies. M. Bizarelli said that certain "foreign companies might have to suffer by their scheme, but he did not suppose that the interests of foreign companies occupied the minds of members, they would not let themselves be taken in by the statements of some of the English newspapers, the war of rates which threatened companies might make need give no alarm." [*It seems to us that such remarks as these indicate a desire on the part of the supporters of this scheme to ruin, if possible, the English companies at the expense of the French taxpayer, without giving the taxpayer any adequate return for his money. Throughout this speech there seems to be a covert attack upon all private English companies, while ostensibly arguing that England as a nation was concerned in the cable system. We might point out that England as a nation has little or nothing to do with the system. It has not—with certain recent exceptions—promoted any foreign system, and the whole work has practically been the result of private enterprise, and it is an enterprise which has benefited the whole world, and not England in particular.*—Ed. E.]

M. Fernand Faure made the most damaging speech against the proposal. He desired with the authors of the scheme the development of the means of communication with the colonies. He agreed with the authors in a desire to see the cable industry developed in France, but he could not see that the financial combination proposed would reach the object at which they aimed. He looked upon the payment of £40,000 a year for five years as certain, but all that had been said had not shown that there was any equivalent return for this payment.

M. Bizarelli said that this payment should not alarm them, that it was to be purely nominal; it would not be operative. There would be nothing to pay; therefore, they might easily vote for this engagement, which was simply and solely a moral support. This implied that, if the Budget Committee had thought the £40,000 was likely to be paid, they would not have dared to submit the draft agreement.

What was it that was actually required by the nominee of the New Cable Company, Count d'Oksza? Was it financial support, or moral support? They must be very clear about this before they committed themselves. They were asked to support a French scheme, with French directors, and a French staff, yet they were taken with the foreigner bearing a foreign name, whom he did not know and whom he was convinced that most of the gentlemen present did not know either.

If a moral support was sufficient, why did they ask for a financial support? This same nominee had been connected with other companies, and had asked the United States for financial support, but the United States granted nothing at all. Brazil was more generous, but in her generosity she did not go beyond moral support, which consisted in authorising the new company to bear the title of Don Pedro the Second Company; but Brazil did not untie her purse strings, and he suggested that France might follow the lead of Brazil, and authorise the taking the name of one of the Ministers, or of any other notable important personage. The Minister could not prove that the guarantee of £40,000 would not be operative, because to do this he would have to prove that the company would have a good business, that it would avoid the breakages of cables so frequent in the Antilles Sea. He ridiculed the idea that the company would forego the subsidy in taking the nett proceeds into account, it being argued that if the gross receipts reached £40,000 a subsidy would not be required. M. Fernand Faure pointed out that generally a company endeavours to live from the receipts it obtains, and applies them to the liquidation of their working expenses. According to the Minister, it will not be so in the present case; but this company, before thinking of its working expenses and its administration, undertakes to pay the interest to the sinking funds. "Such an arrangement cannot be made with seriousness. Who knows the company which is to be formed? Who knows its exact position and its solvency? Up to the present we find ourselves in the presence of one d'Oksza, of whom we know little, and of whom we cannot know much. So here is a company which offers us no guarantee, and which does not dispose a considerable capital. This company goes into business, renouncing at the outset the means of keeping pace with its first working expenses, maintenance, and administration."

M. Fernand Faure went on to say that Count d'Oksza had been connected with other companies which changed their names, and there was no security that a company which presents itself under the auspices of a foreigner should be composed only of Frenchmen. He ventured to think that some foreign influence would always be preponderent.

M. Felix Faure asked, if the guarantee of interest was not to take effect, why they persisted in asking it? It was really asked, he said, because it was necessary to constitute a company. When the convention was presented to them in the month of July they were told that if they rejected the question of urgency they would reject the convention. But they had rejected urgency, and the convention still existed. Since then Count d'Oksza had constituted a company called the Telegraph Company of the Antilles, by a private deed. It was stated that the resolution on the 25th of July, at an

extraordinary general meeting of the shareholders of the Company of Telegraphs of the Dominican Republic, decided to change the name of that company to the Telegraph Company of the Antilles, and the capital of the Dominican Company afterwards became that of the Telegraph Company of the Antilles, and amounted to £8,000. The capital was subscribed by 400 shares of £20 each, 8 persons taking the 50 shares, for which cash was paid. The 350 shares left had been allocated fully paid-up to the founders. The Count d'Oksza applied to the Chamber of Hayti for a concession. It was refused because the persons signing did not offer sufficient guarantee, and at the same time authority was given to the Government to contract under the same conditions with a substantial company. The names of the eight subscribers who paid the £1,000, were given by M. Faure, who said that one of them was a bankers' clerk and another an office boy.

M. Granet, Minister of Posts and Telegraphs, in a long speech, which was principally a diatribe against England and English companies, stated at the outset that the information just given by M. Faure was new to him. He went over the whole of the ground as to the estimated receipts, and reiterated the statement that a subsidy would not be required. He referred to the offers which had been made by English companies for connecting the Antilles with the existing system, and suggested that the English companies had offered landing rights in Brazil, which had in reality lapsed. In reference to the existing agreements mentioned by M. de la Ferrière, it was suggested that, although they were being carried out, they were of doubtful validity in that they had not been ratified by the Minister of Marine; but he subsequently admitted that he would not dispute the existence of these agreements, or that they should be continued for the time specified. Coming to answer the question why the subsidy was asked for if it was useless, the Minister stated that he asked it because the question was one of acclimatising in France an industry which did not exist there, and that, while in England capital had been drawn to these undertakings and experience gained, it would be necessary to make some considerable sacrifices in France in order to foster the industry.

After considerable further discussion the project was referred back to the Budget Committee.

LEGAL INTELLIGENCE.

The Edison and Swan Electric Lighting Company v. Woodhouse and Rawson.

Judgment was delivered on Saturday morning in the second of the appeal cases from the judgment of Mr. Justice Butt, sitting in the Chancery Division. In this instance it will be remembered there was an alleged infringement of the Cheesborough patent, taken out in 1878, on communication from Messrs. Sawyer and Mann, the patentees in America. The appeal was heard before Lords Justices Cotton, Lindley, and Lopes, and was fully reported in *The Electrician* at the time, as was also the original trial in the court below. The Court confirmed the decision of Mr. Justice Butt.

Lord Justice Lindley delivered the following judgment of the whole Court:—The plaintiffs in this case sue the defendants for infringement of a patent obtained by Cheesborough in June, 1878. For the purposes of this action the patent may be described as for the production of a carbon for use in electric lamps. The kind of electric lamp—that is, whether an arc lamp or an incandescent lamp—is not stated, either in the title or claim, but in looking into the body of the specification it is reasonably clear that the patentee is referring to incandescent lamps, and those only. The patentee points out that nearly all obtainable carbon is open to objection by reason of its dissociated character, lack of homogeneity, and by reason of its occluding air or oxygen; in other words, by reason of its porosity. He points out that carbon of the ordinary sort, when heated by the electric current, presents points and lines of unequal brilliancy. He then shows how a carbon free from these defects can be obtained. His method is to heat a pencil of carbon by passing an electric current through it while in a hydro-carbon gas or liquid; he says that the heat required is as high as 7,000deg. Fahrenheit, and that carbon so heated decomposes the surrounding gas or liquid, the carbon of which enters and fills up the pores of the pencil and deposits a perfectly homogeneous layer, generally of a bright grey colour, upon the exterior surface. He says that carbons prepared by this process when heated by the electric current glow with a uniform brilliancy throughout. He says, further, that as the carbon increases in size more current is required to maintain its temperature, and that if the current is gradually increased in accordance with the demand for it there is apparently no limit to the increase in mass of the homogeneous exterior deposit, and that carbon pencils cut from this deposit on the original pencil may be used in the lamps. The patentee then claims the above method of preparing such pencils, and also the substance so prepared for electric lamps. Now it is not denied that pencils thus prepared are better than any before known for the purposes of incandescent electric lamps, and the defendants admit that they make carbon pencils for such lamps by electrically heating them while immersed in or surrounded by a hydro-carbon gas or liquid. The defendants do not admit that they keep up the temperature or increase the electric current, but the evidence shows that they cannot obtain what they want unless they do keep up the tempepature and consequently increase the current. We therefore consider that the admission made by the defendants amounts to an admission of the infringement by them of the plaintiffs' patent, if that patent is good. The defendants, however, contend that the patent is bad on various grounds, but mainly on the ground of want of novelty both as regards the process described and the substance produced, and in support of this contention they rely on certain experiments by Deprez and by Sidot. It will be convenient to deal with this head of defence first. In 1849, M. Deprez, in attempting to volatilise carbon by means of electricity in an atmosphere of carburetted hydrogen, decomposed that gas, and carbon was precipitated on the carbon he was attempting to volatilise, and in the whole apparatus the carbon experimented upon and the lamps were covered with lampblack, which was deposited in flakes; on removing these the carbon experimented on was found to be smooth, bluish grey, and larger than before. Deprez further observed that sugar charcoal, which is light, black, dull, and fragile, became, when experimented upon as above, denser, harder, bright, and *assez solide*—that is, rather solid, or solid enough. In his experiments Deprez used a battery of enormous power, viz., a Bunsen battery of 600 cells. The carbon experimented upon was of various kinds —viz., the charcoal deposited in gas retorts, anthracite, graphite, charcoal prepared by calcining sugar, and charcoal obtained from turpentine. It also appears that sometimes he united the poles of his battery by threads or rods of carbon, and that at other times he suspended similar threads or rods vertically between carbon points at the poles. It is not quite clear which method he adopted in his experiments with carburetted hydrogen. The scientific witnesses examined at the trial apparently thought or assumed that the thread or rod connected the two poles. In considering this experiment it is important to observe that M. Deprez was attempting to fuse and volatilise carbon, and not to produce it or to make it in any shape or form. With reference to his objects the experiment was a failure, and he treats it accordingly. He warns other persons desirous of pursuing his inquiries not to use carburetted hydrogen for the purpose. He pursued the matter no further; he gave no direction as to the best method of making carbon of any kind for any purpose, nor did he point out what precautions ought to be taken in order to avoid a general deposit of carbon over the whole apparatus. He saw that the carbon which he was trying to fuse and to volatilise became smooth, bluish grey, and larger, and that sugar charcoal became denser, harder, brighter, and more solid, but his observations as to the changes undergone by the carbon went no further. He did not examine the porosity of his product; he was not aware of the fact, if it be a fact, that the carbon experimented upon had become less porous or had undergone any change which made it peculiarly useful for any purpose whatever. The fact, however, that the particular form of carbon called graphite had been obtained by Deprez, or could be obtained by means of a less powerful battery than was used by him, was subsequently ascertained by Boltendorf, as appears from the *Jahrsbericht*, or annual report on the progress of chemistry in 1870. That publication gives no further information on the subject. The rest of the evidence relating to Deprez's process consists of the testimony of the scientific witnesses on behalf of the plantiffs. It is worthy of remark that no carbon produced by Deprez's process ever appears to have been made. No one has ever seen it. The defendants did not produce any carbon so made. No one, in truth, knows anything more about it than Deprez himself published. The burden is on the defendants to show that Deprez's process is the same as the patented process, and to show that the substance obtained by him was in all respects the same as the substance claimed by the plaintiffs. The defendants have adduced no evidence to establish either of these propositions beyond what the plaintiffs' witnesses themselves stated in cross-examination. We have therefore only to examine their evidence, and we have carefully done so. Without referring at length to it, we consider—(1) That before the date of the plaintiffs' patent no one had ever intentionally made or attempted to make carbon for any purpose whatever by Deprez's process; (2) that Deprez's process is not a practicable method of obtaining non-porous carbon for any useful purpose; (3) that so far as can be inferred without actually making carbon by Deprez's process the carbon experimented on by him must have been superficially charged with graphite similar in all respects to that obtained by the plaintiffs; (4) that there is no difficulty in making carbon fit for incandescent electric lamps by following the directions contained in the plaintiffs' patent; (5) that carbon made according to the plaintiffs' patent is better adapted for incandescent electric lamps than any other form of carbon known at the date of the patent, and that this fact was never known to or suspected by Deprez or any one else until discovered in 1878 by Sawyer and Mann, who communicated the discovery to Cheesborough, the plaintiffs' assignor. In this state of the evidence we can only come to the conclusion that for all useful and practical purposes the processes are different, and the products are different. By following Deprez's process, carbon resulting from the decomposition of carburetted hydrogen is deposited over the whole apparatus, and is wasted; whereas by following the plaintiffs' process the carbon is deposited where it is wanted, and utilised. The substance obtained by Deprez was a mere scientific curiosity of no known utility whatever; whereas the substance obtained by the plaintiffs is shown to be a valuable article of commerce, of great utility for the purpose of illuminating by incandescent electric lamps. It may be true that Deprez produced graphite, and that the plaintiffs produce graphite, and that long before 1878 graphite was used for incandescent electric lighting, but the fact still remains that of all the known forms of graphite that made by the plaintiffs' process was, in 1878, the best for the purpose they mention, and the carbon got by Deprez's process is not shown to be structurally the same as that made by the plaintiffs, nor that that which Deprez got was non-porous. Such being the view we take of the evidence, it becomes unnecessary to decide what the consequences would have been if the defendants had succeeded in showing that the material produced by Deprez was non-porous and in all respects the same as that produced by the plaintiffs' process. We express no opinion whether in the case supposed the plaintiffs' patent would be bad, inasmuch as it showed how to apply to a useful purpose carbon which neither Deprez nor any one else was aware had the specially useful qualities discovered by the patentee. When such a question arises it will be necessary to consider such cases as "Walton *v.*

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Potter" (1 Web. Patent Ca., 585), "Walton *v.* Bateman" (*ib.*, 613), "Muntz *v.* Foster" (2 Web. Patent Ca., 108), on the one side; and "Losh *v.* Haynes" (1 Web. Patent Ca.), and "" Harwood *v.* the Great Northern Railway Company" (11, H. L. C., 654), on the other. As regards Sidot's process little need be said. His process was entirely different, for he used external heat. The substance he produced, though in one sense the same as that obtained by the plaintiffs, was not so dense and was very inferior to theirs for the purposes of illumination by an incandescent electric light. The difficulty in upholding the plaintiffs' patent turns entirely on Deprez's experiments and not on Sidot's mode of making carbon pencils for arc electric lighting. It remains to consider the objections to the specification and claim. One is that the expression carbon gas or liquid in the claim is ambiguous and too wide and misleading, and it is urged that the expression includes carbonic oxide and carbonic acid, neither of which will do. But every claim in every patent must be read and construed with reference to the specification and not as if the claim were an isolated sentence having no connection with or reference to what precedes it. To see what is meant by carbon gas or liquid we must turn to the specification; and when we do so we cannot conceive that any one reading this patent fairly, with a view to understand it, would ever dream for a moment that carbonic oxide or carbonic acid could answer the purpose or could be meant by carbon gas. The specification clearly points out that carbon is to be deposited, and the presence of oxygen is to be avoided. Reliance was placed on an answer of Sir F. Bramwell. What he said in effect was, "You had better put your question to the chemical witnesses, and not to me." The chemical experts, as might have been expected, ridiculed the notion that any one would think of trying carbonic oxide or carbonic acid. In the body of the specification we find that by carbon gas or liquid is meant what the patentee calls a hydro-carbon gas or liquid, and he states that beeswax, balsam, most oils, if pure, operate satisfactorily, and that almost any hydro-carbon will answer. The appellants, on this, urge that beeswax and balsam and oils are not, properly speaking, hydro-carbons, and that the specification is inaccurate and misleading. The evidence shows that in its technical sense a hydro-carbon is a chemical combination of hydrogen and carbon, and nothing else; and that beeswax, balsam, and oils are not technically hydro-carbons. They contain hydrogen and carbon chemically combined with each other, but also with other substances. But the evidence also shows that, so far as is known, every substance which is a hydro-carbon either in its technical sense or in the looser sense in which the patentee uses the expression, does answer the purpose; and there is no evidence that anything which answers the description of hydro-carbon in either sense will not answer the purpose. In this state of the evidence it is impossible for the Court to say that the specification is open to serious objection, or is insufficient on this ground. The next objection that requires notice is that it is contended that the evidence shows that it is essential to success to increase the temperature gradually, and that the specification is insufficient because it does not point this out. Now the evidence certainly shows that the maintenance of a high temperature is that which distinguishes Cheesborough's process from Deprez's experiment, and although Prof. Dewar points out the importance of a gradually increasing current, neither he nor any other witness says that the temperature ought to be low to begin with and be gradually raised. Their evidence comes only to this—that the temperature must be kept up and the electric current must be increased or the temperature will fall. But the patentee himself tells you this. He says that the temperature must be as high as 7,000deg. Fahrenheit, and the sentence in the specification "as the carbon increases in size more current is required to maintain the temperature" is shown by the evidence to be useless and an obvious truism to those who understand the subject, unless the sentence is understood to be a direction to keep up the temperature; and when we find that in fact no difficulty is experienced by reason of defective instructions on this point, the Court cannot hold as a matter of law that the specification is not sufficiently explicit. If the defendants had shown that the directions as to temperature were not practically sufficient to enable a competent person to make the patented articles the case would be very different; but they have not attempted to do this; they rely on the words used and on the evidence as to temperature already alluded to. This, in our opinion, is not sufficient for our purpose. If the language of a specification is clear enough to guide a competent workman and enable him to obtain the desired result, we cannot see how a Court can hold the language insufficient in point of law. No doubt it is for the Court and not for a workman to construe the specification; but if a workman says it is a sufficient guide to him, and the Court believes him, the Court must hold that as regards clearness of description the specification is, in point of law, sufficient. For the foregoing reasons we are of opinion that there is sufficient originality and novelty in the patented process to support the first claim, and sufficient difference in the thing produced to support the second claim. The appeal is therefore dismissed, with costs.

Mr. Aston: With costs, of course?

Lord Justice Cotton: Yes, of course.

Sir Horace Davey: There is an existing arrangement, which relates not only to this patent, but to the other, by which, on payment of a certain royalty—I need not mention the amount—the injunction is suspended until the delivery of the judgment in this appeal. Your lordships will understand that my clients may desire to consider whether they will pursue the litigation further or not. I am not in a position to ask, and my learned friend (Mr. Aston) is not in a position to consent. I could not fairly ask for an absolute suspension of the injunction, but I might ask that the existing order might continue for a fortnight, to give my clients time to consider whether they will go further or not.

Lord Justice Cotton: That seems reasonable.

Mr. Aston: I am sorry to say, with regard to the arrangement which Sir Horace Davey has referred to, that the defendants have not performed their part.

Sir Horace Davey: Well, Mr. Aston, very large sums indeed have been paid.

Mr. Aston: Your lordships were prepared, I believe, if we had asked you when judgment was given in the first case, to grant the injunction. But of their own accord the plaintiffs instructed me to consent to what appeared to be a reasonable arrangement on the part of Sir Horace Davey that the interval between the judgment in the first action and the judgment in the second might be utilised by the defendants in considering their position. They knew perfectly well that they were open to the possibility, I will say, of having a decision against them, and therefore they ought to be prepared to-day. On two grounds I am instructed to oppose this application. The first is, that as far back, I believe, as January 28th of this year a notice was served on the defendants that an application would be made to the Court to order the defendants to pay what had become due, under the arrangement entered into, on account of accruing royalties. There was at that time £1,300 due. Luckily they then paid a small amount. They had not only themselves opposed us, but had asked for subscriptions from other manufacturers to continue this litigation, and they are therefore not in a position to ask for a continuance of that favourable consideration which up to this time the plaintiff company has afforded them. Under these circumstances I stand upon the rights of the plaintiffs. If your lordships require authority for the fact that the plaintiffs are entitled now as a right to the injunction—

Lord Justice Cotton: I do not think you need go into that. The only question is, what is it reasonable to do while the appellants decide whether to go to the House of Lords or not?

Sir Horace Davey said £1,816. 9s. 6d. had been handed over to the plaintiffs. The defendants had actually paid the sum of £250 since the 28th of January.

Mr. Aston: On account of £2,000. I hope your lordships will not, in opposition to the express desire of the plaintiffs that their rights shall be enforced by the Court in accordance with precedent and authority—I hope your lordships will not put upon them these terms. If the injunction does issue it will then be quite open for the plaintiffs to consider any application the defendants may make even then. I think I am justified in saying that the plaintiffs would be at all events advised to entertain a proposition that is fair. It is not the first time that the plaintiff company has so done. I have here a statement in an affidavit which the defendant himself has lodged, that it was offered them, I believe, after some negotiation, in July, 1886, to work under a license from the plaintiff company. But they wanted a license upon terms that would not recoup the plaintiffs the large outlay of between £300,000 and £400,000 which has been made in putting this invention fairly into operation. Therefore we are really asked on all hands to make concessions. Concessions are made, and we are met by hostility being stirred up amongst rival manufacturers.

Lord Justice Cotton: These defendants, I suppose, are prominent names, but I suppose there are a great many people in the same or a similar position.

Mr. Aston: I might ask to read this affidavit of Major Flood Page, of 13, Albert-mansions.

Sir Horace Davey: Is this fair?

Mr. Aston: We have given notice. There is an affidavit on one side by Mr. Rawson, and of course that is met by an affidavit by Major Flood Page. [Mr. Aston proceeded to read the affidavit of Major Flood Page, which, after stating the effect of the judgment of Mr. Justice Butt, and the terms of the undertaking between the parties by which Messrs. Woodhouse and Rawson agreed to pay a royalty of 1s. 6d. per lamp upon all lamps manufactured by them, declared that the defendants had not complied with the terms of the said undertaking. The defendants paid on account £233. 8s. on September 23rd in respect of lamps made from August 10th to September 9th, and £333. 1s. 6d. on October 30th in respect of lamps manufactured from September 10th to October 9th, but up to January 28th no further payment had been made. The plaintiffs had received nothing from royalties in respect of lamps manufactured or sold between the date of the judgment and August 10th or from October 10th to October 31st, or in the months of November, December, and January, notwithstanding repeated applications. On January 28th Major Page caused a notice to be served upon the defendants, and on the same day received a cheque of £250 only on account, and without any statement or account showing what sum was actually due. The plaintiffs believed that considerable sums were due from the defendants on account of the undertaking, estimating the indebtedness to be, for each month in respect of which no payment had been made, at least as much as was admitted to be due in respect of the months from August 10th to October 9th. The affidavit went on to state that prior to the hearing of their appeals the defendants called a meeting of persons interested in electric lighting, and asked for subscriptions for the purpose of contesting the appeals, on the grounds that they (defendants) were not able of their own resources to prosecute such appeals, and subscriptions were obtained from those other persons. The fact is, my lord, they have not paid royalties for five months.

Lord Justice Cotton: There would be no difficulty, I suppose, Sir Horace, in your clients rendering an account of what they sold, and, therefore, of the sums due on account of royalty?

Sir Horace Davey: I am told that my clients can render an account. They have been busy both with these appeals, and in making up their accounts; but they will render an account in ten days. I am not asking for a suspension of the injunction pending an appeal to the House of Lords, but only for a continuation of the present order for a fortnight.

Lord Justice Cotton: If they will undertake in ten days to render an account of the lamps sold, and to pay the balance then due, we will suspend the judgment for a fortnight on that undertaking.

Mr. Aston: I only wish it to be distinctly understood that the other injunction was suspended until to-day only.

Sir Horace Davey: That I have said.

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COMPANIES' MEETINGS & REPORTS.

Submarine Telegraph Company.

The half-yearly general meeting of the proprietors in this Company took place at the offices, 2, Throgmorton-avenue, London Wall, on the 15th inst., under the presidency of Sir Julian Goldsmid, Bart., M.P.

The SECRETARY (Mr. S. M. Clare) read the notice convening the meeting. The register of shareholders having been sealed, the report of the Directors for the half year ended December 31 last was taken as read

The CHAIRMAN, in moving the adoption of the report, said: It becomes my duty to make a few observations on the report. There has been a considerable increase of traffic for the first time for some period, and I ascribe it myself, to a very great extent, to the war scare on the Continent. But whether this increase is permanent or not I am not in a position to state. We know that there has been a considerable check to business all over the world for many years, and some people are of opinion that that check has ceased, and that we have come to a gradual improvement in all business. I trust that that may be so, and that our business may participate in the gradual improvement. The accidents to cables during the past half year have not been serious, and I believe the reason that that is so is that we have done our best, year after year, to take care that even any fault in the cable should be immediately cut out, so that the cables might be maintained in the best possible condition, and in order, also, that we might be prepared for any eventuality, we have put the boilers of our steamer in thorough repair, and we believe she is as good or better than she was when we first built her. I wish to refer to some complaints which have come to my ears, which I consider to be so ill-founded that it is my business to refute them. One, which was even endorsed by a high postal authority in Germany, was that the messages were delayed through a fault of ours at the time of the great snowstorms. As a matter of fact we are only responsible for the cables, and therefore for the messages conveyed by those cables between the coast stations on this side and the coast stations on the other side; and in France, in Germany, in Belgium, and in Holland, as in England, we have nothing to do with the internal lines by which messages are conveyed to their ultimate destination. At the time of the snowstorms in England numbers of the wires between Folkestone and London and other coast towns broke down altogether, and although our messages were sent from Folkestone and Dover to Boulogne and Calais, or other stations, and duly arrived at the other side of the water, in many cases it was not possible for them to be forwarded, because the land lines had also broken down in France. What did we do in order to show that we were prepared for every possible eventuality? We sent a large portion of our staff down to the coast stations, in order that they might telegraph from there the messages that were delivered in London, and could not be delivered from London to the coast, and which, accordingly, we had to send down by railway to the coast; therefore, if there was a fault it was a fault on the part of the owners of the land lines of England. Now, who are the owners of the land lines in England? Why, the Post Office, and the Post Office admit the responsibility is theirs, therefore I wish you thoroughly to understand if a complaint has been made, as it has been made, that those interruptions which occur through snowstorms and other circumstances could be avoided by having underground lines. It depends on the postal authorities to decide whether those lines should be laid or not. It rests on them, not on us. Another complaint is that messages take a considerable time to send. We have had inquiries made and very careful statistics prepared, and we find that the time we take in order to accomplish the clerical work which is necessary for the purpose of observing the international rules, for the purpose of checking the accounts and all the other matters, is in total not more than 11½ minutes, and that this is by no means excessive, and is far exceeded by the time which is taken by many other persons concerned in telegraphy. I know as a matter of fact that sometimes persons imagine telegraph companies are in fault when it is really a matter of fact that they did not actually know at what time their correspondents telegraphed. Not long ago a gentleman complained that he had telegraphed to Frankfort early in the morning and did not get a reply till five o'clock in the afternoon. Inquiry was made, and it was found that his correspondent at Frankfort was out, and did not return till four o'clock in the afternoon, and did not send his message till a quarter past four; therefore, how he could have received the reply earlier passes my comprehension, as I dare say it will pass yours. Our clerks are as good clerks for telegraphic work as are to be found in any other service, and make as few mistakes as any other company in any other part of the world. I do not deny that now and then a mistake may be made, but we do our best to rectify it and put everything square again. I know the ordinary postal telegrams I receive sometimes contain words which are erroneously written, but I do not immediately say that the Post Office is in fault. I know sometimes mistakes must occur, but I undertake to say mistakes do not occur in our service oftener than, if as often, as in others. I understand, also, some people have asserted that the monopoly which we possess interferes with the sending of messages as rapidly as possible; but, of course, all telegraphy is more or less a monopoly. It would be absolutely impossible to have, say, a couple of thousand different companies across the Channel, in the same way as it would be impossible to have that large number across the Atlantic Ocean. The number of wires to be connected with the English lines must be necessarily limited, as are the number of wires to be connected with other lines; consequently, whether we do the business or not, the number of wires which can be accommodated by the Government lines in any part of the world must be a limited number. I have just been informing myself again as to the exact number of wires we have to the Continent. I find we have 46; that means forty-six different means of communicating with the Continent through our wires. Now, although several of those wires are included in one cable, I think you will see that it is equal to having forty-six single wire cables. Well, that is a large number already for the Post Office to be connected with, and on investigation, efficient as the English Post Office service is, I believe you will find that when delays occur it is owing to inevitable competition for the use of its lines in England, and not to be attributed to the Submarine Telegraph Company. We have lost a valuable member of our Board, the Right Hon. Robert Bourke, who has been promoted to a high office in India. We had hoped to have presented to you a new director of great position, whose services might be of great value to the Company. The matter is not entirely settled, but I am sure that you will leave that subject with confidence in the hands of the Directors. I am sure that every attention has been paid to the interests of the shareholders and of the public, whom we are anxious to serve in the best possible manner. I would add that if anybody has any complaint to make which he thinks is not properly attended to by any member of our staff, if he will only bring it to my notice, or to the notice of any of the Directors, I undertake to say that most serious attention will be paid to him. Every now and then one hears that some member of the public has had to make complaint to which no attention is paid, or that a clerk has not been sufficiently civil to him. I regret if any incivility is ever shown, and I have never had one case proved to me yet. If I can have one proved I shall take the most serious notice of it, and we will examine into any case respecting which the public think they have any grievance in connection with the Company. I think, under the circumstances, you will see that on the whole the report of the proceedings of last half-year is not unsatisfactory, and that we are justified in congratulating you on the state of our affairs.

The Hon. ASHLEY PONSONBY seconded the motion.

Mr. W. O. ROBINSON inquired what was to happen at the termination of the concession, which was now very close at hand. He was sure that that was a matter that occupied the serious attention of all the shareholders, and they would like to know if the Directors had arrived at any definite understanding with the postal authorities as to the renewal of the concession. He was only a small shareholder himself, but a very great number of his clients held shares in the Company; and the question he had asked was constantly being put to him. He knew that on one or two previous occasions the Chairman had not felt himself in a position to give a definite reply, but as the time of the concession was now drawing to a close he thought that if the Directors were in possession of any information, it would be desirable to take the proprietors into their confidence.

Mr. T. S. SODEN inquired when the concession would expire.

Mr. DOLMAN said he thought it would be best that such a matter should be discussed privately, and not in a way that it would get into the public prints. At present, moreover, he thought it rather premature to go into the question.

Mr. FERGUSSON endorsed the remarks of the last speaker.

The CHAIRMAN: As I have mentioned to the shareholders on previous occasions, I have nothing definite to report with respect to the prospects of the Company after the expiration of the concession, which will take place on the 12th of January, 1889. Some of you may have observed that the question was asked of Mr. Raikes, the Postmaster-General, the other day in the House of Commons, and he very properly replied that the matter was occupying, and would continue to occupy, his serious attention. I also had the opportunity of reading the other day a careful report of the speech made by the able Minister of Posts and Telegraphs in France, when he presented his Budget to the Chamber. He discussed this matter before the Chamber very fully, and said he was well aware of the importance of the matter, and that before he arrived at any decision he would carefully consider all the *pros* and *cons* as to it. I might say what I mentioned just now—that we have forty-six wires to the Continent, showing that the public is not ill-served, and that, of course, there must be a limit to the number of wires that can be connected with the telegraph system on any continent. That will have to be borne in mind by any Ministers when they are arriving at a conclusion. We shall do our best to look after the interests of the shareholders, and if when the time comes I have any announcement to make to the shareholders I shall be only too glad to do so. Till then I must ask you to agree with the gentleman who spoke last, who said it was better to leave the matter in the hands of the Directors. He then put the resolution, and it was carried unanimously. Continuing, he said: The next resolution is, "That in accordance with the recommendation of the Board, a dividend for the half-year ended December 31, 1886, at the rate of 15½ per cent. per annum., less income-tax, on the capital of the Company, be declared, payable on and after the 1st March." In moving that I wish to say a word with respect to the reduction of the tariff that has been talked of. You must remember—and the public ought to remember—that the share taken by the Submarine Telegraph Company for the work it does and for the interest on its capital —though we give a very good return now—is very small. Out of the total charge of 25 centimes we take something like six centimes, whereas about 19 centimes go to the two Governments for their shares; and when the public talk about our concession interfering with the reduction of the tariff, they will see, whatever price be paid to us, whether it be more or less, that our share is, comparatively speaking, so small that there is very little ground for attacking us. If they wish to attack any one they had better attack the Governments, whose business, of course, it is to be attacked. I might also say that reductions of the rate have been made from time to time, and we, the Submarine Telegraph Company, have always lent our help to anything that went to the assistance of the public; and I undertake to say that if fair and reasonable arrangements can be made in future as to reductions, and we have to take part in them, we shall do our share as far as the public is concerned.

Mr. SODEN seconded the motion, which was carried unanimously. Mr. Soden afterwards proposed a vote of thanks to the Chairman and

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Directors for their able management of the Company's affairs. He thought the proprietors might safely entrust to the Board the carrying out of any arrangement with the Government which might be contemplated. He thought that the way in which the Directors had conducted the affairs of the Company in the past justified the proprietors in entrusting them in the future.

Mr. HOLDSWORTH seconded the resolution, which was carried unanimously.

The CHAIRMAN: I am very grateful to Mr. Soden and the other gentlemen who express their confidence in myself and the Board. We are, of course, naturally anxious not only to do our best in your interest but in the interests of the public, for I am of opinion that any company that serves the public and consults the interests of the public is really consulting the interests of the company itself. The two go hand in hand, and there is no opposition between them, and I am satisfied that a good dividend is only to be attained by serving the public well and economically.

The proceedings then terminated.

Anglo-American Brush Electric Light Corporation (Limited).

Notice is given that the sixth ordinary general meeting of this Corporation will be held at the Cannon-street Hotel on Thursday, the 24th inst., at 3 o'clock, to receive the report of the Directors and accounts for the year 1886, and to consider as special business, and, if deemed advisable, to pass the following resolutions:—

(1) "That the provisional agreement entered into between the International Electric Company, by Ernest Cooper, the liquidator, of the one part, and the Corporation of the other part, dated 31st December, 1886, and submitted to the meeting, be, and the same is, hereby sanctioned, adopted and confirmed, and that the Directors be authorised to carry the same into effect, with or without modification."

(2) "That in accordance with the terms of the agreement mentioned in the above resolution, the Directors issue to the liquidator, or to such persons, and in such manner, as the liquidator of the International Company shall in writing direct, fully paid £5 shares in the capital of the Corporation, such shares not to exceed in number 1,476."

(3) "That the Directors be empowered to issue and offer at such times, to such persons, whether members of the Corporation or not, and at such premium, but not under par, as they may think fit, not exceeding 10,000 shares in the capital of the Corporation, on which £3 will be called up."

The following is the report of the Directors, which, containing, as it does, the views of one of the largest, if not the largest firm engaged in electrical lighting enterprise, we give almost *verbatim*:—

Although the prospects of electric lighting are in no way inferior to what they were a year ago, the Board cannot refrain from expressing their disappointment that the advance made during the past year has not, for the general and special reasons to be stated, been as great as was expected. It must, however, be borne in mind that there has been depression in most trades, and that in face of general stagnation the rapid advance of a new industry cannot reasonably be looked for. That electric lighting has been prejudicially affected by general trade depression is evidenced by the fact that all other electric companies and firms in this country have experienced with the Corporation the difficulty of creating an effective demand for the electric light, notwithstanding that the desire for the new illuminant is all but universal among those acquainted with the sanitary and economical reasons that urge its adoption. The Corporation have, however, continued during the past year to make steady and real progress in organising and developing their business. This is absolutely essential in face of the keen competition offered by no less than fifty manufacturing and contracting electric light firms in the United Kingdom, and in view also of the heavy demands that will most probably be made upon the resources of the Corporation, when, with the alteration of the Electric Lighting Act of 1882, the long looked for revival of the industry takes place. The technical and commercial character of their operations also continues to improve, and the Board can only regret that these advances, which they feel to be quite as important to the Corporation at the present juncture as the maintenance of dividends, are not more fully reflected in the accounts. The reason for this is largely due to the fact that the various developments, both in manufacture and efficiency, are effected contemporaneously with the carrying out of current work, and that of the expenditure which is not immediately productive of revenue, but which rather partakes of the nature of investment, a comparatively small proportion only has been charged to capital. The Board, however, feel confident that the shareholders will recognise that in framing the accounts as they are presented, the permanent interests of the Corporation have been wisely kept in view.

The arrangements made last year for the conduct of the important relations of the Corporation on the Continent have not altogether proved successful, and the hopes that were entertained as to the expected augmentation of the Continental business have not been realised, owing mainly to the high protective tariffs, and to the keenness of foreign competition, especially in North Germany. The Continent of Europe, however, still offers a wide field for the employment of the resources of the Corporation, and agencies have been established in Italy, Spain, and Portugal, which, it is hoped, will be the means of valuable business in the future. Arrangements are also in progress for taking over the business of the International Electric Company (formerly the Anglo-Austrian Brush Electric Light Company) in Austria and Hungary, and of an affiliated concern in Vienna, on exceptionally favourable terms, which provide for by far the major part of the consideration being paid in shares of the Corporation, and promise highly satisfactory returns upon the capital invested. The properties taken over include the Brush and Lane-Fox patents, which in Austria and Hungary occupy an exceptionally strong position, the well established manufacturing business of Messrs Kremenezky, Mayer and Co., of Vienna, including a valuable stock of plant, and the very important and extensive installation for lighting the town of Temesvar, together with the benefit of the existing contract with the municipality of that town. The purchase will involve the issue of not more than 1,476 fully paid shares to the members of the International Electric Company, being in the proportion of one £5 fully paid share of the Corporation for every twenty £4 paid shares of the International Company. A resolution on the subject will be submitted to the meeting for approval. Permission to register the Corporation in Austria and Hungary is under application, and the Board have reason to congratulate the proprietary upon the prospect of an early establishment of the Corporation in those countries under conditions which justify sanguine expectations.

It is to be regretted that during the past year the Corporation has not been free from litigation. It will be remembered that in the last report to the shareholders, the Directors pointed out the necessity which had arisen for obtaining the recognition by others of the valuable patent rights of the Corporation. In relation to a process of manufacture known as compound winding, most of the leading manufacturers of dynamo electric machines accepted the licenses the Corporation declared themselves ready to grant against payment of a royalty, but two or three firms having declined to do this, it became necessary for the interests of the shareholders and in justice to the licencees of the Corporation to proceed against the manufacturers who were infringing the patent covering the process in question, and the case is shortly expected to be heard.

The other lawsuits into which the Corporation have been unwillingly drawn have arisen out of the judgment given by Mr. Justice Butt in favour of the plaintiffs, in the actions for infringement of incandescent lamp patents brought by the Edison and Swan United Electric Company against Messrs. Woodhouse and Rawson; and by reason of the unwarrantable attack thereupon made on the users of the Victoria lamp, manufactured by the Corporation under their patents. In order to maintain their legitimate business in such lamps the Corporation had to offer to guarantee their customers against actions that might be brought by the Edison and Swan United Electric Company for alleged infringement of their patents. Proceedings having been instituted by that company against one of the customers of the Corporation, the Board had no hesitation in giving instructions for the action to be defended in the name of the Corporation. At the same time acting under the highest legal and scientific advice the Board have, with regret, but without any misgiving as to the result, caused an action to be entered against the Edison and Swan Company for infringement of the Lane-Fox patents.

The Board have deemed it advisable to enter into an arrangement with Mr. Lane-Fox, by which all his rights in his distribution and incandescent lamp patents become vested solely in the Corporation, thereby placing this property on a sound footing as an asset in the books of the Corporation. To effect this it has been necessary to liquidate certain charges in respect of which Mr. Lane-Fox had hypothecated these patents. This has been done in one case by a cash payment, and in another by the allotment to the mortgagee of 1,348 fully paid shares of the Corporation, and the shareholders are asked to confirm the issue of these shares. In further pursuance of the policy initiated in 1885, the Board have, for a small cash payment, repurchased the Brush and Lane-Fox licenses for thirteen counties in England, formerly held by the Hammond Electric Light Company. By this purchase the Corporation have completed the reacquisition of the sole control over the Brush patents in the United Kingdom, save that licenses are still held by local companies at Eastbourne, Hastings, and Dublin.

The Electric Lighting Act Amendment Bill, referred to in the last report as having been drawn up by the committee presided over by the chairman of the Corporation, and proposing to place the undertakers of electric lighting on precisely the same footing as the gas companies, both as regards privileges and obligations, was submitted to the House of Lords last spring by Lord Rayleigh, and Lord Bury having also submitted a Bill in amendment of the compulsory purchase clause in the Act of 1882, the Government introduced a third Bill into the House of Lords and proposed that the three Bills should be referred to a Select Committee, which was done; and the committee, presided over by the Earl of Camperdown, took exhaustive evidence for and against the rival Bills. In the end a Bill was agreed to by the committee, though not unanimously, by which the term of compulsory sale to the local authority was extended from twenty-one to forty-two years, and by which the electric companies were placed under some new but still unfavourable conditions. The Bill was practically adopted by the House of Lords, but the Government soon after resigning, nothing further was done last year. This session, however, Lord Thurlow has introduced a Bill, which, being based in a large measure upon the evidence taken by the Select Committee, may reasonably be expected to receive ready support in both Houses of Parlament. The Bill proposes to amend the present Act by extending the term of purchase by the local authority to forty-two years, and contends for a valution of the goodwill of an electric lighting undertaking on its compulsory purchase by a local authority in precisely the same manner as other kinds of property are dealt with in similar cases. It proposes also to enact certain provisions with regard to electric lines, which appeared from the evidence given before the Select Committee to be necessary in the interests of the public.

During the past year an important reorganisation has been made of the engineering department, and Mr. John S. Raworth, a gentleman of high reputation for a variety of successful installations of the electric light, has been appointed superintending engineer.

Among the more important contracts carried out during the past year may be mentioned the lighting of part of the Indian and Colonial Exhibition, and of the Edinburgh and Liverpool Exhibitions, the latter with the co-operation of Messrs. Holmes and Vaudrey. These installations have

once more served to demonstrate the efficiency of the apparatus of the Corporation, and to confirm the value of its patents. The success of these Exhibition installations has probably contributed to the Corporation being entrusted with the contract to carry out the whole of the arc lighting of the forthcoming Jubilee Exhibition at Manchester, which is to be effected by nearly 600 of their arc lamps, an undertaking which is without precedent in this country.

The manufacturing branch of the business has maintained its reputation in face of keen competition, and during the past year the Corporation have been engaged in developing various novel applications of electricity to the industrial arts. The use of electricity for motive purposes and as a means of transmitting force to long distances, under conditions which make the use of any other power impossible, has become more frequent, and may now be regarded as an important branch of electrical work. It may also be noted that the Brush Electric Company of America have recently constructed the largest dynamo in the world for another distinct application of electricity to industrial purposes, viz., that of the reduction of refractory ores, and the production of aluminium alloys.

To meet the ever changing wants of industry the Corporation have deemed it advisable to take in hand the re-modelling of some of their types of dynamos, electric light fittings and accessories. In conjunction with the Callender's Bitumen Telegraph and Waterproof Company, Major-General Webber, C.B., R.E., the managing director, has carried out a series of experiments in the laying of electric mains underground, which promise to give highly satisfactory results and to meet one great need in connection with the general distribution of electricity from one centre. The advantages of an underground cable system are now so universally recognised as to preclude the necessity of pointing out the value to the corporation of being first in the field in this branch of the business. The apparatus for projecting lights in order to illumine the path of a ship or to protect against surprise from torpedo boats, has now been brought by the Corporation's experts to a marked degree of perfection, and the satisfactory execution of orders for this class of naval plant from foreign Governments have proved the importance and value of the success attained.

Another direction in which notable progress has been made during the past year is that of installing the electric light on board merchant and passenger ships, and there is every reason to hope that the efficiency and economy with which the Corporation are able to carry out such work will secure to them a large share of the extensive electric lighting of ships, which, with the progress of events, is inevitable. The lighting of railway trains also affords a large scope for the profitable investment of capital, and in view of the special adaptability of the Brush dynamo for this class of lighting the extensive utilisation of this apparatus may be looked for.

The amount standing to the debit of property account shows, on balance, a small increase upon last year's figure. The Board have not deemed it necessary to make any provision for depreciation, and have added to the account the expenses incurred during the year for improvement and maintenance of plant and other properties. For the same reasons the Board have added to patents and goodwill account the payments during the year for up-keep of patents. The accounts have also been debited with the cost of the re-acquisition of the Lane-Fox patents, and of the re-purchase of the licenses formerly held by the Hammond Company, as well as with the expenditure incurred in developing the new inventions in the manufactures of the Corporation. The stock account, based upon former valuations, shows a reduction, notwithstanding that a quantity of articles manufactured for the purpose of meeting current and constantly recurring demands have been added to cost prices. This reduction being in a large measure attributable to the sale of obsolete articles, the effect has been to improve to a large extent the character of the asset.

The Board have deemed it advisable to place the expenses incurred during the year in connection with the litigation previously referred to, including technical assistance and retaining fees and payments to a large number of eminent scientific witnesses, to a suspense account pending the final decisions of the Courts. The profit and loss account for the year shows a gross profit of £14,431. 0s. 7d. After deducting all standing charges and expenses, which it will be noted in most cases show appreciable reductions, there remains a balance to credit of the account including the balance brought forward from last year of £1,532. 0s. 9d., which the Directors recommend should be carried forward.

In view of the circumstances here detailed, and of the practical certainty of an increased demand for electric lighting following closely on the revival of trade, the Directors have decided, so far as this year is concerned, on making every effort to lighten the burdens of the Corporation, and have preferred placing many items to current expenditure to showing a larger balance on trading account. In order to place the Corporation in a more advantageous position for carrying out large contracts, and for entering upon such desirable undertakings as may from time to time present themselves, an increase of the available working capital is essential, and a resolution will be submitted to the shareholders for approval, empowering the Directors to allot at such times and at such a premium, but not under par, as they think fit, not exceeding 10,000 shares of the Corporation, on which £3 per share will be called up. The Board recommend this course for adoption by the shareholders, in the full conviction that it is not only preferable to the absorption of the present uncalled capital, but that it will serve to greatly strengthen the position of the Corporation, with the result of securing to it the increased confidence and patronage of the public, and of Governments, both at home and abroad.

The Board regret the retirement from the directorate soon after the last general meeting of Mr. Herbert C. Gibbs, whose business engagements compelled him to discontinue his active assistance to the Corporation. The Directors who retire this year by rotation are Mr. Edward Woods, C.E.; Major-General Webber, C.B., R.E.; and Lord Sudeley, who being eligible offer themselves for re-election. Messrs. Cooper Brothers and Co., the auditors, also retire, and offer themselves for re-election.

Swan United Electric Light Company (Limited).

The following is the fourth annual report of the directors, to be presented at the ordinary general meeting of the Company, to be held at the Cannon-street Hotel, on Tuesday, the 22nd inst., at 12 o'clock noon :—

The balance against profit and loss, which stood at £7,602. 14s. 6d. on 30th September, 1885, has been reduced to £5,834. 3s. 1d. With a view of economising the cost of manufacturing the lamps, the Directors, after careful consideration, decided to concentrate the manufacturing business at Kalk, near Cologne, and to restrict the Lille factory to lamps required for France only. This necessitates a special reserve of £3,000, which is charged to revenue, and apparently diminishes the profit of the year by that amount. The Directors regret that they do not at present see any hope of a fair and equitable arrangement being made with the Edison companies on the Continent. The litigation in Germany is still dragging on, but a decision in the Berlin court will probably be given in the spring. No further progress has been made during the year in the suits in France, Belgium, and Austria. The shareholders are probably aware that the Court of Appeal has upheld the judgment of Mr. Justice Butt, in the High Court of Justice, in favour of the Edison and Swan Company, in the first action against Messrs. Woodhouse and Rawson for infringement. This decision is of great importance to the Swan Company, which is so largely interested in the Edison and Swan Company. The progress of Electric Lighting on the Continent has not been so rapid as was expected; the competition is very keen, but the Swan Lamp holds its own, and the amount of the sales has increased. The Directors who retire by rotation are Messrs. J. S. Forbes and E. W. Batt, who, being eligible, offer themselves for re-election. Messrs. Quilter, Ball and Co. offer themselves for re-election as auditors.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 11th February amounted to £3,758.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts for the week ended 11th February were £3,043, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Feb. 16.		Business Done Week Ending Feb. 16. Highest.	Lowest.
Anglo-American	32,	33	33¼	31½
Do. Preferred	53,	54	53⅜	52¾
Do. Deferred	11½,	12½	12½	11¾
Brazilian Submarine	10⅜,	10⅞	10 13-16	10⅝
Cuba	11,	11½	—	—
Do. Preference	18,	19	—	—
Direct Spanish	2,	2½	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	7¾,	8	8	—
Eastern Telegraph	10½,	10⅝	10⅝	10 3-16
Do. 6 per Cent. Preference	13,	14	13 11-16	—
Do. 5 per Cent. Debentures, 1899	104,	107	107½	105
Eastern Extension	10½,	10¾	10¾	10 9-16
German Union	8¾,	9¼	9 1-16	8¾
Globe Telegraph and Trust	4⅝,	4⅞	4 15-16	4 11-16
Do. Preference	11⅝,	11⅞	11⅞	11⅝
Great Northern	13⅛,	13⅝	13 5-16	—
Indo-European	34,	35	34¾	—
Reuter's	6¾,	7¼	—	—
Submarine	190,	200	—	—
West India and Panama	¾,	1	13-16	11-16
Do. 1st Preference	8½,	9	8¾	—
Western Brazilian	7½,	7¾	7 11-16	7½
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¾,	⅞	—	—
Oriental	3-16,	5-16	—	—
United Telephone	12½,	13	12¾	12 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¼,	2¾	2 7-16	2½
Do. (fully paid)	3¾,	4¼	4¼	3¾
Swan	1½,	1¾	1 11-16	1⅝
Maxim Weston	3-16,	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	38,	39	39	38
India Rubber, Gutta Percha, and Telegraph Works	21½,	22½	22¾	22

TRAFFIC RECEIPTS FOR JANUARY, 1887.

Companies.	Jan., 1887.	Jan., 1886.	Increase.	Decrease.
Cuba Submarine	3,200	2,891	309	—
Direct Spanish Telegraph	1,888	1,700	188	—
Eastern Telegraph	53,435	57,317	—	3,882
Eastern Extension	39,331	39,699	—	368
Great Northern	20,400	19,880	520	—
West Coast of America	5,875	—	—	—

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NOTES.

THE CANARY ISLANDS.—The Port of Las Palmos, one of the chief towns of the Canary Islands, is being provided with electric light by public subscription.

BRIGHTON.—At Brighton two tramps have been prosecuted for stealing boots from a shop which had been fitted with an electric alarm, and by means of which the thieves were discovered.

THE NEWCASTLE EXHIBITION.—Messrs. Nicholson and Jennings, of 159, Old Kent-road, write to inform us that the incandescent lighting in the North Gardens at the Newcastle Exhibition has been placed in their hands.

"ELECTRICITY IN THE TREATMENT OF DISEASE."—Messrs. E. W. Allen send us a copy of "Electricity in the Treatment of Disease, a practical guide to its application, what it is, and what it will accomplish," by James R. Turner, M.R.C.S.

ELECTRICAL ENGINEERING FOOTBALL CLUB.—The next smoking concert in connection with the above club will be held at the Masons' Hall Tavern, Basinghall street, on Wednesday, March 9th. Tickets can be obtained from the hon. treasurer, 12, Princes-street, Hanover-square, W.

LECTURE AT WELLINGBOROUGH.—On Feb. 18th a lecture on "Electrical Energy and its Uses" was delivered at Wellingborough, under the Gilchrist Educational Trust, by Mr. Wm. Lant Carpenter, B.A., B.Sc. The lecture was followed with great attention throughout by a crowded and interested audience.

"THE METAL TURNERS' HANDY BOOK."—Messrs. Crosby Lockwood and Co. send us a copy of the second edition of "The Metal Turners' Handy Book," a practical manual for workers at the foot lathe, embracing information on the tools, appliances, and processes employed in metal turning, by Mr. P. N. Hasluck, A.I.M.E.

STOCKHOLM.—The Royal Palace at Stockholm was supplied with an electric lighting plant twelve months ago. On the occasion of some recent festivities an additional engine and dynamos were temporarily installed, and the great drawing room was illuminated with no less than 172 arc lights of 2,000 candle-power each.

"PRACTICAL ELECTRICITY."—We have received from Messrs. Cassell and Co. a copy of "Practical Electricity: a Laboratory and Lecture Course for First Year Students of Electrical Engineering, based on the Practical Definitions of Electrical Units," by W. E. Ayrton, F.R.S., Professor of Applied Physics at the City and Guilds of London Central Institution.

ANOTHER LAWSUIT.—The Brook's Telegraph Construction Company profess a claim to the sole right of using telephones upon metallic circuits. An action has been commenced against the Bell Telephone Company for infringing the rights of the Brook's Company in this matter. The claim is one which it would certainly be very difficult to sustain in this country, whatever may be the result in America.

THE LIGHTING OF THE BRIGHTON PAVILION.—A long discussion took place at the meeting of the Brighton Town Council, on Thursday, on the report recommending that the Pavilion rooms should be lighted by electricity, and eventually an amendment was carried instructing the Pavilion Committee to bring up a more comprehensive report, dealing with the warming as well as the lighting of the rooms.

LECTURE AT BROCKLEY.—On Friday evening, the 18th, a lecture on "Electricity" was delivered in the school room of the Wesleyan Church at Brockley, by Mr. H. S. Price, M.I.M.E. The lecture was illustrated by means of apparatus which had been lent for the occasion by Messrs. Paterson and Cooper, G. Binswanger and Co., the Stanhope Telephone Company, and Messrs. Nicholson and Jennings.

BRADFORD.—At a meeting of the Gas Committee of the Bradford Corporation on Saturday, the 12th inst., a resolution was passed expressing the opinion that it was desirable that an installation of electric lighting to serve a district within a radius of a quarter of a mile of the Bradford Exchange should be made by the Corporation, and directing that Mr. J. N. Shoolbred, the electrical engineer to the Corporation, should be instructed to report on the requisite works and their probable cost.

THE PANAMA CANAL.—The *Standard's* Paris correspondent has had an interview with M. de Lesseps on the subject of the Panama Canal, and its projected competitor the Nicaragua Canal; and was told with respect to the former that the electric light was being employed in constructing the canal, the work being carried on night and day. The employment of the electric light upon this undertaking would, he said, make it possible to complete in three years the work which would otherwise take six.

THE PARIS EXHIBITION OF 1889.—The sub commission appointed to consider the question of lighting the International Exhibition to be held at Paris in 1889 has reported favourably upon a project submitted by M. Georges Berger, which involves the employment of every known means of illumination. The total amount of light to be furnished is estimated at 2,850,000 standard candles, which is said to be upwards of five times the intensity produced by the whole of the gas lamps in Paris.

ELECTRICITY FOR ADVERTISING PURPOSES.—Shopkeepers whose windows are lit with incandescent lamps can obtain a cheap and effective advertisement in the following way—any electrical man can rig it up for them. Get a few lamps with coloured glass, and mount them upon a circular disc; fix this disc upon the end of the armature shaft of a small motor, and make suitable brush contacts with the main leads, so that the same current drives the motor and lights the lamps while they are rapidly rotated with the disc. The effect can, of course, be varied at will by changing the position of the lamps.

DUPLEX TELEPHONY.—The *Indian Engineer* states that Mr. McGuire, of the Telegraph Office at Umballa, claims to have made an important discovery in connection with the working of a duplex system of telegraphy. The new process dispenses with the differential apparatus, and only requires the single acting instrument, thus effecting an economy of no less than fifty per cent. in the working of a line. If the discovery bears the test of experiment its results will doubtless be of universal importance. Meantime, the duplex system is shortly to be extended very considerably in Madras and other parts of India.

STRANDED *v.* SOLID WIRES.—A correspondent writes:—"With reference to your note in *The Electrician* of February 18, we are glad to see that the compilers of the so-called 'Phœnix' rules are moving with the times, and that they suggest the use of stranded wires in certain cases. For several installations which my firm has sent in tenders during the last two years, and for which the specifications were drawn by Mr.

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W. Massey, it has been insisted on that stranded cables must be used down to the single light conductors. The reason given is as follows:—'Cuts-out do not prevent fires from arcs caused by broken wires.'"

TELEGRAPH CLERKS.—In the House of Commons on Monday last, Mr. H. S. Wright asked the Postmaster-General whether the title "clerks," as mentioned in the Telegraph Act, 1868, carried with it the salary and privileges of clerks in the Post Office, to which department telegraph clerks are attached? Mr. Raikes replied that there were in the department over which he had the honour to preside a variety of clerks, male and female, with a corresponding variety of salaries. The Act to which the hon. member referred did not define the salary or privileges of any officer or clerk in the Post Office. He might state that the class of persons in question had had their salaries considerably augmented since they were incorporated in the Civil Service.

THE BOLLMANN DYNAMO.—Since its first appearance, says *Industries*, some two years ago, this dynamo has been greatly improved, the manufacture having been undertaken by Messrs. Egger and Co., of Vienna. The latest machine turned out is constructed for 1,500 lamps of 16 candle-power, and gives 100 volts at 750 revolutions, the total output being 100,000 watts. The total weight of the machine is 3 tons 12 cwt., which is at the rate of a little over ½ cwt. per 1 horse-power output. This satisfactory result is obtained partly by the high speed and partly by allowing the very large current density of 4,600 amperes per square inch of the armature conductor. The armature is of the disc pattern, contains no iron, and in arrangement resembles somewhat the well-known Ferranti machine; but the winding is somewhat more complicated.

SPIDERS.—Some time ago electric lights were placed in front of the Treasury and other public buildings in Washington, and a striking effect is said to have been produced. Unfortunately, however, spiders discovered that game is plentiful in the vicinity of the new lights, and that they may there ply their craft successfully both day and night. In consequence, as Mr. G. Thompson writes to *Science*, their webs are so thick and numerous that portions of the architectural ornamentation are no longer visible, and "when the webs are torn down by the wind, or fall from decay, the refuse gives a dingy and dirty appearance to everything it comes in contact with." We would suggest that a small boy be employed, at a salary of a dollar per week, and armed with a long-handled broom, in order to wage unrelenting warfare upon the spiders and their webs.

ELECTRIC MOTORS FOR WORKING HEAVY GUNS.—General Sheridan, of the U.S. army, has recently spoken very strongly in favour of the employment of electric motors for the manipulation of heavy guns. Electricity, as a source of power, does away with the cumbersome hydraulic or pneumatic machines, with their more or less exposed connecting pipes. A wire is much less likely to be broken by the fire of the enemy, and if broken can be repaired with the utmost facility, while the repair of a pipe containing water or air under pressure is a very different matter. It will be remembered that some two years ago experiments with the Maxim system were made by our own War Office, under the superintendence of Mr. W. H. Massey. Satisfactory results were said to have been obtained; but we do not know whether the system has been actually adopted.

RAILWAY RATES FOR ELECTRICAL MACHINERY.—It will be gratifying to those interested in the electrical industry to learn that, as a result of the agitation which was commenced in the spring of last year by the Anglo-American Brush Electric Light Corporation for an alteration of the railway classification as regards the carriage of dynamo and other electrical machinery, it has been decided that the Clearing House classification for apparatus of this description will now be—"not packed, 3rd;" "in cases, 2nd." The reduction of rates effected by this alteration represents a very considerable saving in the expenditure for carriage of dynamo and other electrical machinery, and the thanks of the trade are due to the Anglo-American, and to the firms who have energetically co-operated with them, in obtaining this trade concession from the railway companies.

THE EDISON "MUNICIPAL" SYSTEM.—In some of the American towns the streets and roads in suburban districts are lit by incandescent lamps on what is known as the Edison "Municipal System." This is simply a series circuit supplied with constant current, and is almost exactly similar to the arrangement which has met with such success at Temesvar. The Edison Company does not, however, provide any second lamp to be switched into circuit automatically on the extinction of the first. Instead of this, the cut-out merely short circuits the lamp terminals, and the current consequently rises throughout the system. This is observed at the engine room, and an additional lamp is there switched into circuit, while a lineman is despatched to replace the lamp. The current employed is 4 amperes, and the machines are usually built for 1,200 volts, so that not more than 70 to 80 20 candle-power lamps are run on one circuit.

PANEGYRIC.—It was not until this present year of grace that we have been enabled fully to realise how irreparable was the loss which the civilised world sustained in the death of Benjamin Franklin in 1790. "Had he lived much longer," says an American electrical journal," he would have anticipated every electrical invention of the nineteenth century, and have had a priority claim to every patent." The amount of anxiety, expense, and trouble which would thus have been saved is simply incalculable, and though the lawyers would have been poorer, nobody else would much mind that. The title of Benjamin Franklin to a niche in the Temple of Fame is, however, too absolute to be discounted by any quantity of bombast, although considering that up to the time of his death static electricity had alone been made known, it will appear to some people that the assertion made by our contemporary requires a good deal of gulping to get down.

SECONDARY BATTERIES IN THE UNITED STATES.—The "Electrical Accumulator Company" is now employing a staff of 125 men at their factory at Newark, N.J., and are turning out 500 cells per week. The raw material employed in the construction of this quantity amounts to 12 tons of pig lead, six tons of peroxide, and 200lb. of rubber plugs. The factory is fitted with many ingenious contrivances for increasing the efficiency and rapidity of the work. In the department where the plates are trimmed, power is furnished by an electric motor driven by accumulators. The cells manufactured by this company are, we believe, practically identical with the well-known cells of the E.P.S. Company. We notice that the company offers to guarantee a return of 80 per cent. of the *current* with which they are charged. Unless the actual state of affairs is expounded a little further for the benefit and instruction of the consumer, a guarantee of *current* return can only be described as misleading in the extreme.

ELECTRIC TRANSMISSION OF ENERGY AT PARIS.—A correspondent of *Industries* states that a small installation for distributing 10 horse-power is now in successful use at the Gare

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de l'Est in Paris. Some works, where there is steam power, are situated on one side of the station building, and some repairing workshops situated on the other side were formerly supplied with power from the steam engine by means of a line of shafting and belts passing through the cellars. The vibrations were so great and the noise so unpleasant that the company resolved to do away with the shafting and substitute electric transmission. A compound-wound 10 horse-power dynamo is generating the current, which is delivered to seven small motors, each working one of the tools. To provide for changes of speed each motor is fitted with a resistance box and rheostat. The whole installation has been put up by the Compagnie Electrique, and works with complete success; the dynamo and three of the motors have already been running for five months, without having cost a penny for repairs.

GAS COMPANIES AND ELECTRIC LIGHTING IN THE STATES. An American journal, *The Progressive Age*, which devotes special attention to gas lighting affairs, has recently published the result of a series of inquiries which they have made with regard to the adoption of the electric light by gas companies. About twenty local gas companies who had substituted arc lamps for gas for street lighting replied to the effect that they were perfectly satisfied with the change, and that a notable increase in the consumption of gas had resulted. The leading electric light companies also reported upon the progress of their business in this direction. The American Company stated that they were now in correspondence with a large number of prominent gas men in various parts of the country, and that they expected during the coming year to arrange terms with some forty or fifty of the best known gas companies in the United States. The Thomson-Houston Company furnished a list of twenty-three local gas companies who had adopted their system. About fifteen similar cases were reported by various other electric companies.

EDISON LAMPS IN THE UNITED STATES.—The New York Edison Electric Light Company states that the total number of Edison lamps now in use in the United States is about 400,000, averaging 16 candles each. Taking each such lamp as the equivalent of a six-foot gas jet, this represents a light equal to the consumption of 57,600,000 cubic feet of gas per day. The total capacity of the gas companies supplying New York is said not to exceed 36,000,000 feet per day, so that assuming these figures to be correct the Edison lights in use in the States would be sufficient for the supply of a city half as big again as New York. On the other hand we find that calculations made in the gas interest show a somewhat different result, the conclusions arrived at on this side of the account being that "the gas companies of New York could furnish more light than all the Edison incandescent lamps in the country, and that too, without working to their full capacity." The discrepancy is not of the least consequence, but what is of importance—especially to the gas companies—is to consider what the relative position is likely to be in, say, ten years' time, if the present rate of progress of electric lighting in the States be maintained.

ELECTRICAL COMMUNICATION WITH LIGHTSHIPS.—The Board of Trade have appointed the following as a committee to inquire into and report on the desirability of electrical communication between light-vessels and the shore, with the special object of facilitating the saving of life at sea:—The Earl of Crawford, Colonel King-Harman, M.P.; Sir Edward Birkbeck, M.P.; Rear-Admiral Sir George S. Nares; Mr. C. Cecil Trevor, Assistant-Secretary to the Board of Trade; Mr. Thomas Sutherland, M.P.; Captain J. Sydney Webb, Deputy-Master of Trinity House; Captain H. M. Hozier, Secretary to Lloyd's; and Mr. Alfred Holt. The committee will be instructed also to consider whether a system of electrical communication should be applied to outlying lighthouses; whether the experience gained by the present cable to the "Sunk" Light Vessel has proved of sufficient value to justify the cost; whether the system should be further extended; and whether it is desirable that any of the stations to which the system is applied should be also used as signal stations for commercial purposes. The first meeting of the committee will be held at the Board of Trade on Monday, the 28th instant. Mr. T. Waddon Martyn has been appointed secretary to the committee.

POST OFFICE TELEGRAPHS.—A Parliamentary paper was issued on Wednesday last showing the gross amount received and expended on account of the telegraph service during the year ended March 31, 1886. The total amount received was £1,832,401, showing a balance of expenditure over receipts of £45,137. The chief item of receipt is £1,974,852, the gross amount received by the office in respect of telegraphic messages, rentals of private and special wires, which has to be reduced by £229,796, paid to submarine telegraph companies and moneys refunded. The chief item of expenditure is £1,733,104 expended by the office in respect of salaries, rent, and maintenance. The balance already mentioned by no means shows the real excess of expenditure over receipts, for a sum of £326,417 has to be added as one year's interest on the £10,880,571 of securities, and this makes the deficiency for the year £371,554, which may be compared with £362,767 of the previous year. Altogether the deficiency from the beginning of 1872 to March 31, 1886, has been £2,553,009. The only year when anything like a balance occurred was in 1881, when the deficiency was only £984. This deficiency rose next year to £112,524, and has gone on rising (with a very considerable leap between 1883 and 1884) until the present year, which is the highest of all. A Supplementary Estimate for £514,650 for the Civil Services and Revenue Departments was issued on Wednesday. Of this, £236,000 is required for the Post Office, £122,000 for the Post Office telegraphs.

LONG-DISTANCE TELEPHONY IN FRANCE.—The success of the Brussels-Paris Telephone Line seems to have given a great stimulus to the movement in favour of long-distance telephone lines in France. It is satisfactory to note that up to the present time our own country is distinctly in advance of the rest of Europe in this matter. The Northern and Midland districts and the South of Scotland are already well provided with inter-urban lines, and the West of England and South Wales are rapidly advancing in the same direction. In France the question of long-distance telephone lines is entirely in the hands of the State, and, owing to an early preference for the Van Rysselberghe system, very little progress has been made. In fact, the line from Paris to Rheims long remained the sole representative of the system. Now, however, several special lines are about to be built, the first on the programme being from Paris to Rouen and from Paris to Havre and Troyes. In point of distance the latter line will considerably exceed anything similar in this country. We have always held that the application of the Van Rysselberghe system to long lines, which were built originally for telegraphic purposes, cannot possibly be accomplished without impairing the efficiency of each service. But it is happily true that the converse does not hold, and if at any time it should be worth while to do so, there can be no doubt these special telephone lines may without difficulty be made simultaneously to subserve the purposes of telegraphy. If the telephone had happened to precede the telegraph, the Van Rysselberghe system would have proved simply invaluable.

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EARTHQUAKE IN THE RIVIERA.—On Wednesday morning, the 23rd inst., a severe shock of earthquake occurred, having its centre in the Riviera district. The disturbance seems to have extended over a wide area, having been felt as far south as Rome, and northwards as far as Geneva. The actual centre was probably situated under the waters of the Gulf of Genoa. The damage inflicted all around the shores of that bay seems to have been very severe indeed, and the island of Corsica also suffered. The town of Diano Marina, a place not far from Genoa, is reported to have been utterly destroyed, and the total number of lives lost in this district is at present estimated at fully 1,500. At Bajardo, a village situated on the top of a hill, the inhabitants sought refuge in a church, which fell in, burying 300 people in its ruins. At Mentone six separate shocks were experienced, the first occurring at 6 a.m., and the others succeeding each other at intervals of three hours. Not much damage was inflicted in this district. The same remark applies to the towns of Cannes, Nice, and Monte Carlo, although at Nice the panic among the populace was excessive. On the other hand, it is stated that at Noli Albissola and Porto Maurizio, hundreds of lives are believed to have been lost. A later account states that the first shock occurred at Nice at 5:37 a.m., and lasted more that one minute. A second and a third shock of less severity followed almost immediately, and a fourth and much slighter shock at 9 a.m. Direct telegraphic communication between Marseilles and Italy is suspended, and the cable to Corsica is also broken. Slight shocks were felt at Lyons, and some telegraph wires were broken in the Avignon district.

PROF. H. ROBINSON ON THE ELECTRIC LIGHTING ACT.—In his inaugural address to the Society of Engineers Prof. H. Robinson, referring to the Electric Lighting Act of 1882, observed that "it had tended to check electric lighting companies by imposing conditions more onerous than those that had been put upon gas undertakings. It was impossible to obtain capital for a novel system like electric lighting when the local authority or vestry had powers of purchase more stringent than those obtained in regard to gas or water undertakings. The check, however, that was given was well deserved, owing to the too hasty way in which conclusions were being jumped at by those interested in promoting electric lighting. At a time when too sanguine a view was taken as to the economy of electric lighting, the Board of Trade were doing a service by imposing conditions which were not inconsistent with the financial success of the system, if what was then stated by the promoters had been correct—which, however, was very far from being the case. Recent improvements in the direction of simplifying and economising the production of electrical energy, I think, render desirable the removal of the hampering restrictions of the Act, by which encouragement will be given to the utilisation of the system with advantage. The public are now alive to the fact that the illusions which at first existed about economy have passed away, and that electricity recommends itself for employment for numerous purposes on the ground of convenience. The beauty and convenience of the various forms of lamps will prove too attractive to cause any question of cost to deter the more wealthy classes from indulging in the luxury of applying electric lighting to their mansions. The employment of it in this way will involve a greater use of either gas, steam, or water for working the dynamos, and will tend to an increased demand for the various means of actuating motors. I think that electric lighting provisional orders, under the Act of 1882, may now be prudently sought for by local authorities themselves who are free from the penalties imposed on outsiders."

NEW ELECTROLYTIC TREATMENT OF COPPER ORES CONTAINING LEAD AND SILVER.—Mr. Eugene Marchese, an Italian engineer, has lately introduced and described, in the *Revue Universelle*, an improved method of separating, by electrolysis, the copper from lead and silver compounds or mattes, by using anodes of the metallic sulphides prepared from the substance to be treated. The following is a description of the process:—The ores containing the copper and the argentiferous galena are generally accompanied with gangue matter, more or less soluble in acids. In this case the mass is melted in the crude state without any previous roasting. This operation produces a species of matte in which are concentrated the copper, lead, silver, iron, and sulphur contained in the ore, the metals being present in the state of sulphides. An average sample is then taken, and the exact contents in iron and copper are determined. This done, one portion of the charge is cast directly into slabs to be used for the anodes, and the remainder of the charge is granulated and then roasted. The proportion of the cast slabs to the whole remainder of the roasted charge is so arranged that they contain in weight of iron two equivalents of this metal for every three equivalents of copper contained in the matte to be roasted; or, in other words, that the slabs shall contain six parts by weight of iron for every ten parts by weight of copper contained in the remainder of the charge. The object of the roasting is to oxidize the copper salts, which are then treated with dilute sulphuric acid, furnishing a solution of sulphate of copper with some sulphate of iron. This solution serves as the electrolyte. The special novelty of this process consists in the attacking of these anodes by the electrolyte, the iron being corroded by the copper solution. This action generates an electromotive force, which, added to that supplied by the dynamo or other generator, permits the use of a much feebler machine than would be required if the solution of cupreous sulphate had to be decomposed between electrodes that would not be attacked by the bath. In casting the plates for the anodes, a copper wire is suspended in the moulds so that connection of each plate is easily made with the circuit wire. The anodes are set vertically to the number of 15 or 20 in appropriate vats; they rest on cross slats fixed from 6in. to 8in. above the bottom. Between each anode is placed a copper plate acting as cathode. The sulphuric acid required would in general practice be obtained in the ordinary manner from the sulphurous gases generated in roasting the ores. One main condition of this process is the continual circulation of the electrolyte between the electrolysing and the lixiviating vats. When the electric current is turned on, the copper of the anode is deposited on the cathode, while the iron attacked is changed to sulphate of iron. The electromotive force developed by these reactions is utilised in the decomposition of the sulphate of copper in the liquid and its doposition on the cathodes. As the liquor loses its copper salt, it is repassed over the roasted ore, again taking up the copper from the latter, to be again deprived of it by the cathodes. In this manner practically the whole copper is extracted. The precipitates that form at the bottom of the vats contain free sulphur, oxides and sulphides of iron, lead, and silver, also occasionally a small percentage of copper oxides. In cases where these latter are still present in such an excess as to interfere with the subsequent smelting of the silver lead, these precipitates should again be roasted and lixiviated in conjunction with a new change.

THE AURORA.—The *Standard* having published an article upon the Aurora, *apropos* of a recent brilliant display in the North of Scotland, has received the following interesting com

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munications upon the subject. The first, signed H. G., is as follows :—" Sir: With regard to the question of the Aurora causing any sound, I well remember a small party of us going out upon the ice, far away from the ship, to try if we could detect any sound during a brilliant display then taking place. For some time we noticed none, then first one and then another declared he could hear the faint rustling sound we had been led to expect. I believe we should all have returned to the vessel firmly convinced that the Aurora did produce the sound had it not occurred to one of the party that the sound might be caused by our own breath, congealed by the low temperature and passing through the air in minute particles. We held our breath ; the Aurora gave no sound. We breathed again, one or more at a time, and the same rustling sound, like a faint wh-i-sh-sh was heard, and after that time the experiment was often repeated, and the Aurora often watched, with the result of convincing all on board that the Aurora itself produced no sound whatever, and that other observers might have been deceived as we had been at first." The second is from Captain Walter Dickson, R.N., who sailed with Admiral Morse's expedition to the Antarctic regions in 1844. This expedition completed the work of Sir James Ross, and explored for the first time very nearly one-third of the Antarctic circle. Capt. Dickson's letter is as follows :— "Sir: In the Antarctic voyage of H.M.S. 'Pagoda,' in the beginning of 1845, I had ample opportunity of observing several magnificent displays of the 'Southern Lights,' and can bear testimony to their marvellous brilliancy and diffusion and gorgeous colouring. In the far South, beyond the Antarctic circle, where we spent some days in February, in longitude 40 deg. East, the prolonged daylight prevented their being seen, but in the beginning and middle of March, between 56 deg. and 60 deg. S latitude and 70 deg. to 100 deg. E longitude, the Aurora was of almost nightly occurrence, and often in extraordinary splendour in the south-west and west. I quote from my journal :—'March 7. The spectacle was most magnificent; columns of light shooting up from the southern horizon illumined the sky all round, and were reflected on the clouds and the water with all the brilliancy of the full moon. They were to be seen in nearly every quarter of the Heavens. Most of them pointed convergingly to south-south-east. Some formed on the clouds in the zenith splendid luminous arches, concave to the south, which alternately brightened up and were dissipated with great rapidity. Nearer the horizon the columns of light were straight, streaming up in flashes or flitting along in broad sheets of dazzling brilliancy, in which the more prominent prismatic colours were seen clearly defined.' This beautiful and awe-inspiring meteor generally appeared about 9 o'clock, exhibited its full splendour at midnight, and remained visible till daybreak. It was of most essential service in a most perilous navigation, for in that portion of the Antarctic ocean the icebergs are very numerous and of enormous dimensions. No noise was ever heard in connection with those grand illuminations, nor was any marked magnetic disturbance observed, although observations on the magnetic intensity, as well as declination and inclination, were made daily whenever practicable, and were, indeed, the *raison d'être* of the expedition, which was the supplementary one of that of Sir James Ross a few years previously."

Mr. Sprague, of New York, and his Critics.—Mr. Sprague, of New York, is a gentleman who has devoted much time and attention to the study of electric motors, and has designed several types which have met with considerable success in the United States. In our issue of October 15th, 1886, we devoted considerable space to an account of Mr. Sprague's proposals for an electric railway system. Mr. Sprague has recently published a good deal of algebra on the subject of electric motors, much of which has been reprinted in this country. We did not think it necessary to reprint the articles in our own columns, inasmuch as they contained nothing essentially novel, the ground having been already well worked over by Mr. Kapp, and to a certain extent by Profs. Ayrton and Perry as long ago as the year 1882. In holding this opinion we of course do so without prejudice to any claim which Mr. Sprague may make to have arrived at his own conclusions independently, and possibly at an even earlier date. We merely record the fact that he is not entitled to the honour of having been the first in this country to establish the propositions in question. The publication of these articles in this country led to some discussion, in which views similar to our own were set forth, and Mr. Sprague has at length thought it desirable to take some notice of the matter, which he has done by writing the following letter to several of the American journals :— "Sir: An English paper, the *Telegraphic Journal and Electrical Review*, has seen fit during the last three or four months to make several attacks upon myself. These attacks have not only been made by the editor of the paper, under, it seems, necessarily a gross misapprehension of the facts, but a number of communications have been published, which have been copied by your own and other papers, from Profs. Silvanus Thompson, Messrs. Ayrton and Perry, and Mr. William Mordey, in which they, too, have joined the hunt and raised the cry against the originality of my work. When the numerous duties which occupy my time will permit I will answer, in such detail as I think is necessary, these assaults. Meanwhile I have to make the following proposition, which, if these gentlemen believe what they say, they will either accept, or else apologise for the statements which they have made. I propose that Mr. Thompson, or Mr. Ayrton, or Mr. Perry, or Mr. Mordey—or any one or all of them—and myself, shall build two electric motors, which motors shall be submitted, one to John Hopkinson, of Westminster, London, and the other to Henry Rowland, of Johns Hopkins University, Baltimore, the machines to be duplicates. I mention these gentlemen because they are recognised as men of the highest scientific attainments, and as absolutely beyond and above all question as to their character and the reliability of any test or report which they may make. The conditions for building these motors shall be as follows :—1. They shall be from working models and designs dating back not less than five (5) years, as sworn to by not less than three (3) witnesses. 2. There shall be no change whatsoever in the machines from time the working drawings leave the table until the machines are completed. 3. Such machines shall be completed within eight (8) weeks from the time they leave the drawing board, or by May 1st. 4. These machines are to be tested, first, for the maximum horse-power for a given weight; and, second, they shall be tested for efficiency with any given weight per horse-power, such weight not to exceed forty (40) pounds. 5. The motors to be of not less than 10 horse-power capacity for ten hours continuous run. These machines to be given to the gentlemen who make the tests, or to any institute which they may designate, the entire expenses of the tests to be paid for by the competitors in equal proportions. I shall not now enter into any discussion whatsoever of the question that has been raised by these gentlemen; I wish them to answer explicity and without equivocation this challenge to build machines on models of 1881, without any change whatsoever from that date to this.—Frank J. Sprague."

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INCANDESCENT LAMP MANUFACTURE.—IX.

BY J. SWINBURNE.

Flashing.

The next process is one of great importance, as success in manufacture depends very largely on producing lamps in large numbers of exactly the right electromotive force. The process is so called because, when gas at the pressure of the air is used, the carbon is only heated to a white heat for a moment, otherwise the carbon is deposited too quickly.

The object of flashing is not only to reduce the carbon to a particular resistance, but to harden it and to destroy as nearly as possible its property of occluding gases. The carbon is held in a clip and put in a flask or jar filled with coal gas or hydrocarbon vapour, and is then raised to a white heat electrically. The gas is decomposed in the immediate neighbourhood of the heated body, and carbon is deposited. If the carbon is heated in a vacuum or in a gas which contains no carbon the resistance falls, and the carbon gets much harder and more durable, and loses its power of occluding gases. There are, then, two distinct actions when a carbon is flashed. A high temperature is necessary in flashing, because the deposit is then grey and hard, while at a lower temperature it is black, bulky, and soft, and does not reduce the resistance without increasing the diameter of the carbon too much.

Flashing does not, as is often supposed, make a carbon homogeneous or of even resistance along its length. If a carbon is perfectly uniform in cross-section to begin with, but of varying specific resistance, the parts of highest resistance become hottest, and more carbon is deposited there than elsewhere, thus reducing the resistance locally. This goes on until the whole carbon is reduced to the desired resistance, but if carried on indefinitely it would eventually reduce the resistance until the carbon was at the same temperature all over. If the carbon were not thickened most where the greatest deposit took place it would remain of uniform section, and would then have even resistance throughout its length. Suppose a carbon of varying diameter and, say, uniform specific resistance is now taken. Before flashing its resistance will not be even along its length ; a millimetre of thin carbon will have a higher resistance than the same length of thick carbon. Suppose electricity to be passed through, the carbon will get hottest at the thin parts, because there is not only greater resistance per millimetre of length but less cooling surface. Carbon will, therefore, deposit more quickly on the thin parts, and the tendency will be to make the thin parts of such low resistance that they are at the same temperature as the thick parts, and this demands that the resistance of the thin parts per millimetre must be less than that of the thick parts, so that the heat formed may be in proportion to the surface, or nearly so. Flashing, then, tends to make a carbon that will run at the same surface temperature all over, which is not of necessity a carbon of uniform resistance.

This is really what is wanted in a lamp, as the durability of a carbon depends on its temperature, or rather on the tempera- of its hottest or weakest part. The equalising action of flashing is interfered with by convection currents in the flask, and by the process being stopped when the resistance of the whole carbon is reduced to the required value.

In a lamp it is required that the carbon should all be at the same temperature, and that that temperature should be the highest the carbon can safely stand, for the higher the temperature the higher efficiency of the lamp. As will be more fully explained under the head of *Testing*, lamps are tested at the same efficiency, which means that if the vacuums are the same, the carbons are at the same temperature, and appear the same colour to the eye. Now, it is also necessary that a batch of lamps should run at the desired electromotive force. We therefore have the following conditions:— All lamps must run at the same temperature and same efficiency. The power needed to maintain a given temperature or efficiency depends on the radiating surface only, and not on other conditions, such as thickness, specific resistance, &c., of the carbon. The power needed varies as the surface of the carbon. The word efficiency as commonly used in connection with incandescent lamps has no meaning. By efficiency in these articles will be meant the light emitted in candle-power divided by the electrical power in watts, the carbon being supposed to be a vertical cylindrical rod, whose light is measured in a horizontal direction. Commonly efficiency is taken backwards, as, for example, 4 watts per candle. It will be here taken so as to correspond with other efficiencies, and what is generally called 4 watts per candle will be called ·25 candle per watt, or an efficiency of ·25, or a quarter. Some makers make to several efficiencies, which causes confusion, but probably allows customers to get lamps that suit their own individual notions as to efficiency and life. Thus, a customer who thinks long life alone is to be aimed at may order a 16-candle 100-volt lamp giving ·25 c.p.w., and another customer, who thinks he can halve the cost of electric lighting by running his lamps bright, buys the same lamp as a 20 candle-power lamp, taking higher electromotive force and giving a higher efficiency. It would be much simpler if makers agreed to adopt a nominal efficiency, such as ·3 c.p.w., and worked to that. At present such expressions as "20 candle-power lamp" have no meaning, because the efficiency is not also given, and any lamp is a 20 candle-power lamp at some efficiency if it does not break before it gives 20 candles.

A very convenient efficiency is ·3 c.p.w., or as it would be called $3\frac{1}{3}$ watts per candle. This is a very fair efficiency for ordinary running, and will be assumed throughout these articles as normal, so that by a 16 candle-power lamp will be meant a lamp that gives 16 candle-power at ·3 c.p.w., the carbon being round, and all at right angles to the direction of measurement of light. Thus all 16 candle-power lamps at the normal efficiency will have the same surface, and all 20 candle-power lamps 25 per cent. more surface, and so on.

To return to the flashing. The first thing to do is to get the surface of the carbons right. If the lamps are to run together at the same electromotive force and to give the same candle-power they must have the same surface and the same resistance, and they will all take the same current. Lamps will run together perfectly, without giving the same light and taking the same current, if they are at the same efficiency, which means at the same temperature and colour. Thus, a 100-volt 10 candle-power lamp and a 100-volt 20 candle-power lamp will run together. The 10 candle-power lamp will have a resistance of 300 ohms and a current of 0·33 ampere and 33·33 watts, while the 20 candle-power will have a resistance of 150 ohms and a current of 0·66 ampere and 66·66 watts, and twice the surface of the 10 candle-power lamp. Let it be assumed for the present that a batch of 96-volt 16 candle-power lamps are on order. The carbons are first examined to see that they are all exactly of the same diameter. Most likely they will be found to vary slightly.

Measuring the diameter of carbons is very difficult, as the material is so soft that the least difference of pressure makes a difference in the apparent diameter. Thus, if a carbon is ·009 of an inch, or nine mils., and it is measured as ·008, or one-thousandth of an inch wrong, the lamp will come out ten per cent. wrong in candle-power, and about five per cent. wrong in electromotive force.

A screw micrometer with a ratchet head is the best instrument for measuring. The screw must be made to turn very freely, and the ratchet must be set so as to run directly the least pressure is exerted on the carbon. With care, carbons should be easily measured within half a mil., which means within two per cent. of the electromotive force intended in the case of 50-volt lamps, and a somewhat larger chance of error in thinner carbons. If the carbons are homogeneous they can be measured by weighing.

If the carbons are not all of the same diameter, they must be sorted out into batches. Each diameter has a certain corresponding length for a 16 candle-power lamp, and a little extra must be allowed for mounting.

A table hung on the wall of the flashing room shows the length needed for each diameter for each candle-power. The table is drawn up so as to allow for a constant addition of whatever is needed for mounting, the extra length varying according to the mode of mounting. The table gives the

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length of the curled carbon, and the gauge is set to it. The writer's gauge is shown in Fig. 1. It is of wood with a movable brass piece. The face is marked so that the brass piece can be set. The loop of the carbon rests in the notch in the brass, and the legs project over the end as shown. A pair of flashing clips then grip the carbon, the gauge ensuring that exactly the right length is taken.

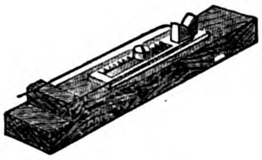

FIG. 1.

The carbon is now taken, and its resistance reduced to the resistance given on the table for 96 volts and 16 candles. This resistance is calculated to allow for the extra length. The finished lamp is to be 175 ohms. It is generally safer not to flash down to the right resistance at first, but to leave a slight margin, and to flash down to the exact resistance after mounting, as little inaccuracies are certain to creep in. Errors in the lamps are due chiefly to three causes. Error in measurement of the diameter of the carbon, flashing to the wrong resistance, and to defective testing. Errors may also creep in through mounting wrong lengths, and through lighting the lamps on the pumps too soon, and through wrong testing. Errors through wrong measurement of the length of the carbons are not likely to occur.

1886.

The accompanying illustration, Fig. 34, shows a direct-current shunt-wound dynamo, as constructed by Messrs. STATTER and Co. The machine was designed with a view to get a large output for a small total weight, and is commercially known as a 10-unit machine. It is intended to give 50 amperes, having a difference of potential at the terminals of 200 volts, at 1,340 revolutions. The electrical efficiency under these conditions is given as 90 per cent. The machine has been tested as a 12-unit machine, giving 60 amperes with a slightly

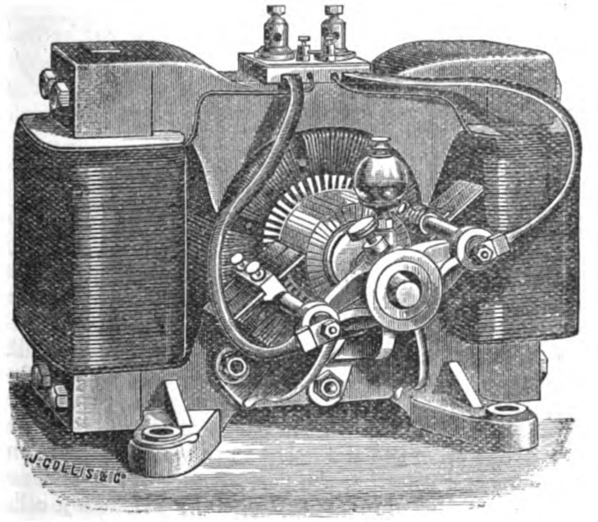

FIG. 34.—The Statter Dynamo.

increased number of revolutions, but we give the figures of the normal output. Its size over all is 30in. by 16·5in. by 26in., and the total weight is 8cwt. 1qr. 14lb., thus giving 9·38 watts per lb. of machine. The armature is of the Joel disc type, modified by the makers, with an axial length in this particular machine of $8\frac{5}{8}$in., a diameter of $9\frac{1}{2}$in., and a radial depth of $1\frac{3}{4}$in. The resistance is given as 1·9 ohms after a long run of testing as a 12-unit machine, and the current density as 3,100 amperes per square inch; watts lost in armature, 470. The peripheral speed at the normal revolution is about 3,600ft. per minute. The bearings are of phosphor-bronze, and have a length equivalent to four and a half times their diameter.

This review of dynamos would not be complete without a reference to the excellent machines built by Messrs. MATHER and PLATT. The experiments of the Drs. Hopkinson with these machines have been so recently before our readers, that

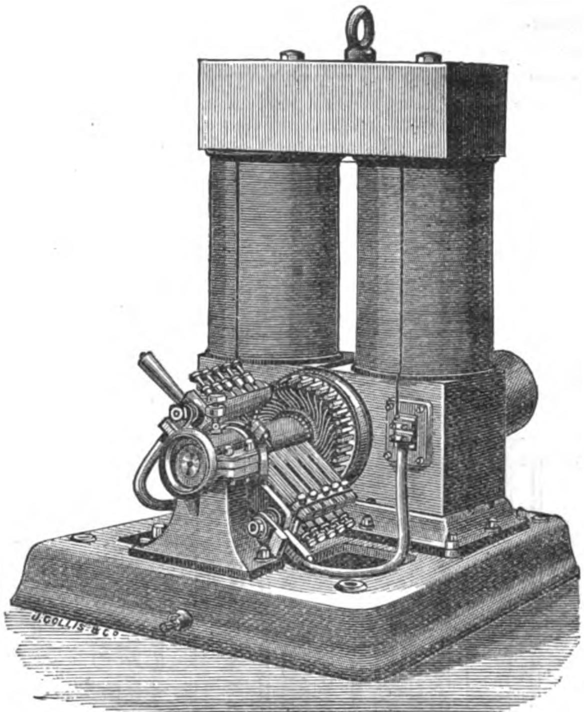

FIG. 35.—Edison-Hopkinson Bar Armature Dynamo.

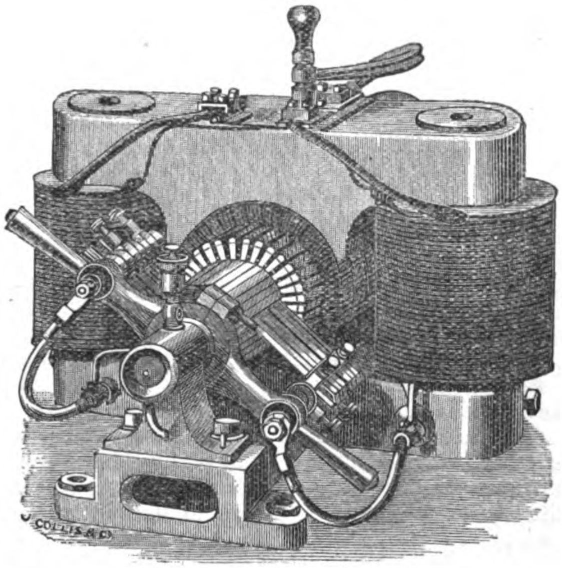

FIG. 36.—Mather and Platt's "Manchester" Dynamo.

in this case, as in some others, we shall content ourselves with giving illustrations of the two principal types of machines built by this firm. Fig. 35 shows an Edison-Hopkinson dynamo of the bar armature type.

In some of these machines the armature is constructed with copper bars, instead of winding with strands of insulated wire. By this means the amount of copper on a given size of armature is largely increased, and, consequently, the resistance

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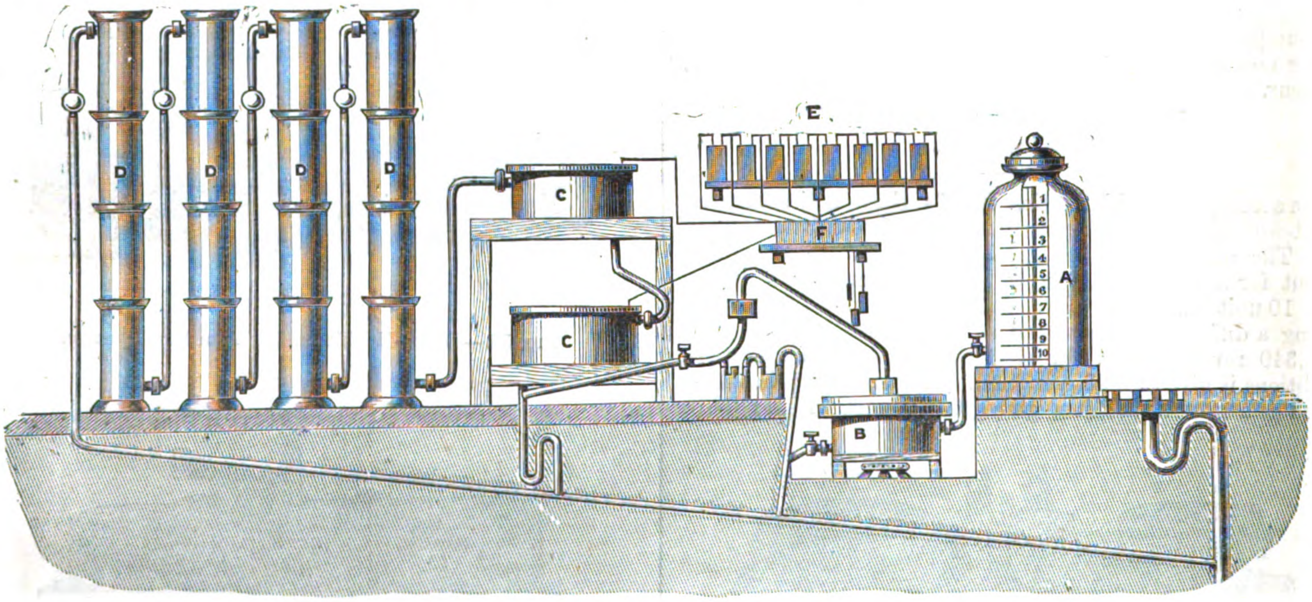
diminished, which enables a much larger current to be carried with the same economy. It is claimed that the bar armature has the further advantage that at no point of the armature do two bars in which the electric pressure is widely different come into close proximity, which much diminishes the possibility of a cross or breakdown of insulation ever occurring, should the dynamo not receive proper attention or be subject to very sudden variations of load.

Fig. 36 shows the type of dynamo constructed by this firm called the Manchester dynamo. The machines are specially designed to secure great compactness, and to occupy little floor space. The centre of gravity of the moving parts is low, giving great steadiness of running and ease of fixing. Perfect ventilation of the armature is claimed, which enables the machines to be worked with the full load without undue heating.

The bearings are all gunmetal and are extra long, and the shafts of Bessemer steel. In some of the larger sizes the commercial efficiency exceeds 91 per cent. The commutators are built up of copper bars, insulated with mica, and there is no sparking whatever visible at the brushes. With the exception of the two smaller sizes, there is a pair of brushes on each side the commutator, so that one can be adjusted or removed without disturbing the current. The holders have a spring-forward thrust and hold-off catch. The Manchester dynamos for incandescent lighting direct are all compound-wound and are self-regulating from one lamp up to the full load. The construction of the "Manchester" dynamo allows it to be wound in a way specially suited for arc lighting. To maintain the steadiness of the arcs the machine must have considerable resistance in the armature. This can be readily obtained in the "Manchester" dynamo without undue heating, by reason of its perfect internal ventilation. Moreover, the armature being wound after the Gramme method, there is little risk of breakdown of insulation of the armatures, as no parts are in close proximity in which the electric pressure is widely different.

THE UPWARD BATTERY—A NEW TYPE.

The Upward chlorine battery, which attracted so much attention a few months since when it was first introduced by Messrs. Woodhouse and Rawson, has recently undergone considerable modification at the hands of the inventor, with the result that, while the arrangement remains unaltered in principle, it has been found possible to effect some important simplification in matters of detail. In the previous arrangement the aspirator was not only a weak point, but also one which added considerably to the cost of the apparatus. In the new pattern the aspirator has been got rid of altogether by the simple device of placing the cells C in the figure *between* the chlorine generator B and the reservoir D. It is thus rendered impossible for air to find its way into the cells so long as a proper supply of gas remains in the reservoirs. This alteration is unquestionably a marked improvement.



The New Type Upward Battery.

In the next place it will be noticed in the figure that the chlorine cells (C) have been reduced to two in number. They are now made in the form of large cells, having extremely low internal resistance, and the zincs stand in open porous cells, which have only to be filled with pure water as before. This arrangement again reduces the cost of the apparatus, but it obviously introduces a difficulty of a serious character, for the primary battery will now possess an E.M.F. of only 4 volts. How, then, are the secondaries to be charged? It will be seen that Mr. Upward has attacked the problem with commendable courage, and if, as we shall hope, his success is commensurate with his courage, then the Upward battery will certainly have a great future. In the figure, E represents the secondary cells, and below this will be noticed a piece of apparatus marked F. This consists of a clockwork switch, by means of which each of the secondary cells is connected, one at a time, and for a fixed period, to the terminals of the primary battery. Half an hour is the period preferred by Mr. Upward at present for charging each cell, and at the end of that time the clockwork switch automatically changes over to the next cell. A device of this nature is one which can only be justified by practical success. We are assured that the apparatus works to perfection, and, for our own part, we should be sorry to cast any doubt upon the statement until we have had further opportunities of witnessing the performance of the apparatus.

If, as represented in the figure, eight secondary cells are employed, it will take four (or eight) hours to charge the whole battery, and if the discharge is commenced at any intermediate period it is obvious that the cells receive a differential treatment which does not conduce to the health of the battery as a whole.

For this reason it seems to us that, other things being equal, it would be better to divide the charge of each cell into shorter periods of 5 or 10 minutes each. This, however, is a question which will easily be determined by experience.

The remainder of the apparatus has undergone very little alteration, and the details are clearly shown in the figure.

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LITERATURE.

Practical Electricity: a Laboratory and Lecture Course for First Year Students of Electrical Engineering, based on the Practical Definitions of the Electrical Units. By Prof. W. E. AYRTON, F.R.S. With numerous illustrations. [Cassell and Co., 1887.]

[FIRST NOTICE.]

This is a new book, on a new plan, from a new standpoint. We are not among those who by seeing the preface of a book and the author's name can decide as to its value; and especially is it the case with a work of this kind that a casual examination may lead to an erroneous opinion. It is because we received this work but a day or two ago, and have not had time to do more than glance through it, that we divide our notice of it, giving at the moment a general idea of its contents, while reserving for future consideration a critical examination of those contents. Prof. Ayrton not only possesses undoubted originality, but he is able to do what many original workers are unable to do, viz., to place his results and conclusions in a lucid and systematic manner before the scientific world. Perhaps he may have a little of that belief in self which is so characteristic of schoolmasters and naval officers; but, as a matter of fact, the world believes in a man very much as he believes in himself. No doubt, however, that men who have made their mark in any profession have, in the ordinary nature of things, caused some of their competitors in the race to look with keenness into all they do. Hence the wish "that mine enemy would write a book," in order to find some vulnerable point in his armour. Prof. Ayrton has written a book which, from the slight examination we have been able to give it, we are prepared to say is good. That some of his conclusions may be altogether wrong goes without saying; but, taking it as a whole, the student will find the book contains far more useful practical information upon instruments used by practical men than any other work in this or any other language.

The work deals almost entirely with the instruments—tools we should say—used in electric manipulation, what the tools are used for, why such tools are used, their defects and excellences, as well as their construction.

The book commences by stating that we really know nothing about the so-called electric current, only about certain phenomena which result from the action of the electric current, phenomena having magnetic, chemical, and heating properties. It is concluded that the best way of measuring an electric current is electrolytically, and thus we get the definition of the unit current, the ampere, "as the current that deposits 0·00111815 gramme, or 0·017253 grain, of silver per second on one of the plates of a silver voltameter, the liquid employed being a solution of silver nitrate, containing from 15 to 30 per cent. of the salt." The conventional way of indicating the direction of the current is that "the current flows through the liquid (dilute sulphuric acid) with the hydrogen." In practice the electrolytic method has disadvantages which make the galvanometric method preferable, and this is clearly shown by the author, who in the first chapter explains the methods of calibrating the galvanometer, and introduces the student to graphic methods of showing results of experiments. The second chapter specially deals with galvanometers, treating the important question of calibration at considerable length. The tangent law and the sine law are experimentally illustrated, and various forms of galvanometer are considered. Similarly, throughout the remaining chapters, a fundamental text, so to speak, is taken for each chapter, and considered from the standpoint of practical measurement. Thus we have treated successively, difference of potential, resistance, and current generators. The latter chapter, viz., Chapter V., does not enter at length into questions outside of batteries and the various measurements connected with batteries. This chapter is followed by those on "Insulation," and "Quantity and Capacity." The last two chapters are still more closely allied to practical work, as they discuss the commercial instruments and the measurement of power.

It will be seen from this brief review of the contents of the book that we are correct in stating it is a work altogether different to the ordinary treatises on electricity; in fact, we think the title "Electrical Measuring Instruments; their Theory and Construction," would have more closely indicated the contents than the present title. Previously it has been said that Prof. Ayrton has the power to make his conclusions lucid and clear, and if one critical remark may be made here it will be to the effect that in this particular the author is not seen at his best in this book. One feature should not be forgotten, that the book throughout contains numerical examples to illustrate the text, with questions to be solved by the student.

Electricity and its Uses. By J. MUNRO. 2nd Edition. [Religious Tract Society].

We are glad to see that this little book has reached a second and revised and enlarged edition. The number of really satisfactory books dealing with electrical subjects for the benefit of "the general reader" is few and far between (to adopt a hackneyed *mis*-quotation). Mr. Munro's book, we need hardly say, exhibits a thorough knowledge of his theme. It can be read with interest and advantage from cover to cover, and it is well calculated to impart clear general ideas on the subject of the modern developments of electricity. In future editions, however, we should be glad to see those chapters dealing with the applications which are more distinctively known as "electrical engineering" still further revised (not without a little judicious excision), and brought down to date.

L'Annee Electrique; ou exposé annuel des travaux scientifiques des inventions et des principales applications del'electricité a l'industrie et aux arts; par PH. DELAHAYE. [Paris: Baudry et Cie.]

This useful work, which has now reached its third year of publication, presents an epitome of the electrical progress of the past twelve months. Notwithstanding the general consensus of opinion that the year 1886 was not marked by any striking advance in the applications of electricity, yet it is impossible to glance through the 380 pages of this volume without being struck with the enormous amount of energy which is now being concentrated upon the detailed development of electrical appliances and apparatus. The selection of subjects appears to us to have been made with good judgment, but as the greatest part of the information here given has already appeared in our own columns, possibly our opinion upon this point is not wholly unbiassed. M. Delahaye's descriptions of apparatus are as a rule remarkably clear, although the work would undoubtedly gain largely in value if it contained diagrams and illustrations.

CORRESPONDENCE.

FIRE INSURANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to your correspondent, Mr. G. T. Pardoe who asks why the American fire offices forbid the use of resin in the soldering of electric light leads, I suggest that it is because of the difficulty experienced in making good joints when this method of soldering is employed.

It requires a good deal of time and patience to make a joint with resin, especially if the leads are of large size. If soldering by solution is used, quite double the number of joints can be made in the same time, and what is more important the joint so made is far more reliable.

The great point to insist upon is that the soldering iron shall be hot enough, and that the solution shall not be applied until the iron has first touched the joint.

If this precaution be observed, the "acid" or "salts" will only come in contact with the wire where it is most wanted, and where it is exposed to the greatest heat. The result is that the acid or saline flux is entirely driven off and volatilised. There will, therefore, be no "creeping" of the acid or corrosion of the wire as mentioned by your correspondent.

With regard to the corrosion of copper, it may be pointed out that this metal is only corroded by acid or salts in the *presence of air*, and, therefore, supposing a careless workman did leave some solution in contact with the wire, but still covered the joint properly, there would be no corrosion.—Yours, &c., R. FREDERICK YORKE.

Redhill, February 22, 1887.

[CORRESPONDENCE *continued on page 351.*]

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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CITY NOTES.

Our readers will find these Notes separate from the more technical and News Notes, and placed together after reports of meetings.

CONTENTS.

Notes ... 341
Incandescent Lamp Manufacture.—IX. By J. Swinburne. Illustrated ... 346
Retrospect of the Past Year. (Concluded.) Illustrated. ... 347
The Upward Battery—A New Type. Illustrated ... 348
Literature ... 349
Correspondence ... 349 & 351
ARBITRATION *v.* LITIGATION ... 350
Diehl's Induction System for Operating Incandescent Lamps on Arc Circuits. Illustrated ... 351
Maxwell's Theory of Electricity. (Concluded.) Illustrated. ... 353
The Verification of Faraday's Law of Electrolysis with Reference to Silver and Copper By W. N. Shaw, M.A. ... 355
Companies' Meetings—
India Rubber, Gutta Percha, and Telegraph Works Co ... 358
Anglo-American Brush Electric Light Corporation ... 359
Swan United Electric Light Company ... 360
City Notes, &c. ... 362
Companies' Share List ... 362

ARBITRATION versus LITIGATION.

The principle and practice of arbitration, which, for the settlement of Trade disputes, especially between employers and employed, have risen greatly in public esteem of late years, seem to make very little progress in cases of disputed claims to the profits on capital and invention. As regards capital, so long as any of it is left to go to Law with, to the Law capitalists appeal. Probably this tendency has been rather increased, and the inclination to accept the verdict of an arbitrator lessened by the multiplication of Limited Liability Companies. Individual capitalists, in the exercise of their own good sense, will often submit their disputes to arbitration where a company representing capital will not. Whatever may be the merits of the Act which brought these companies into existence, a cautious and economical use of the shareholders' money is not one of them. Litigation is the favourite means of settling differences between joint-stock undertakings, and arbitration is hardly ever thought of. This is owing partly, no doubt, to the inherent difficulty of bringing large bodies of shareholders to think and act with one mind in respect to their interests, partly to the circumstance that the magnitude of the risks as a whole attending legal proceedings is not so keenly realised by the shareholding item as by the proprietor or proprietors of a business worked on the unlimited liability principle.

These remarks apply not less to the case of proprietary inventions than to profits on ordinary business capital. Latterly it has become the rule, rather than the exception, for inventors to dispose of their patents to a "company" formed expressly to work them; and the consequence is that once in possession of the patent it becomes a matter of life and death with the joint owners, not only to defend it against all new comers, but to sustain it against the claims of older inventions, the very existence of which was probably unknown to them before the purchasers had irretrievably committed themselves to the younger patent. Such, indeed, are the facilities for disposing of his invention, and such the uncertainty of the patent law administration, that an inventor's first care after securing his patent is to get rid of it as quickly as possible. There can be no doubt that he often does so with the knowledge that his work is not yet perfected, and sometimes with a shrewd suspicion that, perfected or not, it will be charged with infringing some other patent of earlier date. He escapes these risks, and, as regards electrical patents of recent years, the market has been so good that he, moreover, gets as much by selling his rights as he would have made by working them himself. The purchasers' position is quite the reverse of this. Their patent is final; they can do nothing for it but stick to it as long as they may. And this they do by going to Law, or, more often, by defending a suit which, bar accidents, they know must go against them.

In this desperate situation the owners of a telephone patent or an electric light patent, embodying principles which, of course, are quite novel to the limited intelligence and limited responsibility of its proprietors, are not in the humour to either arbitrate or wind up. As to winding up, they may as well wind up in bankruptcy as out of it. The Law is uncertain; and should the worst befall them, they have the satisfaction of flinging their boots at the heads of their pursuers when a barefooted flight is the only mode of escape left to them. Arbitration at a stage earlier than this would be the resource of sensible men; but the multitude of councillors, in whom wisdom was once to be found, were evidently not a multitude of modern shareholders (limited); and as arbitration is a little more certain to give a verdict on the merits of a case rather than on the legal technicalities with which it may be surrounded, the choice naturally favours litigation. In no other way can we account for the host of electrical lawsuits with which our columns are pregnant from week to week and all the year round. In only one instance, looking over the records of the past eight or nine months, do we find the inventor fighting his own battle and succumbing with a good grace to the defeat which inevitably awaited him. Probably he had conscientious convictions as to his own originality, which, if taken as evidence of his possessing a conscience, would account for his not having put all his supposed rights and actual risks, for a consideration, on to the shoulders of other people.

The majority of the suits to which we are referring are companies' cases—one big company charging another big company with invading the other's patent, often the accused company bringing a cross suit against the plaintiffs for doing the like by their rivals. The suit of the ANGLO-AMERICAN BRUSH COMPANY in respect to compound winding last July is, we believe, still unsettled. Another case, where the company just named were the defendants in respect to the JABLOCHKOFF light last August, appears to be legally in the same condition, though the immediate occasion for it may have disappeared. Then there are the curious cases in progress on the Continent nominally between EDISON on the one hand, and SWAN on the other, although these two names are linked as one firm in this country, notably in their suits against Messrs. WOODHOUSE and RAWSON, which commenced in May, 1886, and after pro-

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longed trials and appeals have yet, it would seem, to be settled in the House of Lords. Add to these the never ceasing crop of telephone cases, mostly instituted by the UNITED TELEPHONE COMPANY, and usually with success, against anybody who presumes to make a telephone that has any chance of speaking as well as their own. How the position of the English company will be affected by the gigantic suit now pending in the States is more than we can say; but come what may it can hardly be expected that the sacred character of the telephone-microphone combination will remain unimpaired. Our advice all along in regard to these law suits has been to effect a compromise by arbitration or mutual concession. It has only been followed, we believe, in one instance, quite recently, and this because the plaintiffs arrived at the conviction that they could not upset the pretensions of the defendants. Such, at least, is the construction put upon the occurrence by the latter, although to our thinking neither party has strictly any moral or legal right to the position it claims.

Compromise, however, is the one element in a process of arbitration which the parties most dread. The stronger of the two—that is to say, the party in possession—has no fancy for sharing its exclusive rights with any and every interloper. But nobody advises such a course. What is advisable is that when mutual rights are rather questionable, when both are open to challenge, and when a decision at Law might tend—as they have already tended—to weaken the validity of all alike, compromise is clearly the course which an arbitrator would recommend, and which business principles would approve. We have named only a very few of the numerous cases now pending, or about to be commenced; and of the majority of these it may be safely said that a vast amount of money would be saved to all the people concerned if only they would consent to submit themselves to the decision of any fair-minded arbitrator. This, at all events, is certain, that many a bankrupt and defunct company might have escaped with a whole skin and a full purse had arbitration instead of litigation been the disposer of its life and fortune. Shareholders in Electrical Companies should take warning.

MAGNETIC HEATING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was very much interested in your note upon this subject, and also in the letter of Mr. Blathey. My own experience leads me to think that the heating of armature cores is often largely due to direct magnetic friction, and not solely to Foucault currents. About twelve months ago the following facts were brought under my observation. A dynamo of new type was built originally with four turns of wire to each bar of the commutator, which consisted of only eighteen parts. Under these conditions the armature heated very considerably, and almost as much on open circuit as with full current. The coils of the armature were then cut and a seventy-two part commutator was affixed, thus leaving only one turn of wire for each bar; the result was that the machine ran beautifully cool, without the least tendency to undue heating.

Now there is only one explanation of these facts that suggests itself to me, which is this:—Consider only the armature field due to the current in the coils. Then, as a particular bar of the commutator comes under the brush, the field is carried round with the coil over an arc equal in the first case to one-eighteenth part of the circle, but at the instant that the brush leaves this bar the field is suddenly brought back to its first position. It is this extremely sudden motion of the field over an arc of 20 deg. in the direction opposed to that of the rotation to which I attribute the heating effect in the first case. When the number of bars had been increased fourfold, of course the extent of motion of the field had been reduced to one-fourth. I shall feel greatly obliged if you, Sir, or any of your readers, would have the goodness to point out any discrepancy which I may have overlooked in this explanation.—Yours, &c., C. F. W.

[We fear that our correspondent has overlooked the bearing of his own observation, that in the first experiment the heating was "almost as much on open circuit as with full current." According to his own theory we take it that he would expect to find the heating proportionate to the strength of the armature field, which does not seem to have been the case. Again, although it is true that the extent of the oscillations of the field are reduced four-fold in the second case, yet it must not be overlooked that they recur with four times the frequency. The explanation of the experiment that suggests itself to our mind is the somewhat prosaic one that in the first instance some of the coils happened to be more or less short-circuited.—ED. *E.*]

POLLAK CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to your correspondent's inquiry in your last week's issue concerning the Pollak battery, we beg to inform him that we are the sole licensees of this battery, which is not, however, suitable as a substitute for the Grove battery, as its rate of discharge in the sizes made does not exceed ¾ ampere.—
Yours, &c., G. BINSWANGER AND CO.
(per J. H. Wood.)

DIEHL'S INDUCTION SYSTEM FOR OPERATING INCANDESCENT LAMPS ON ARC CIRCUITS.*

The demand created for the incandescent electric light in the United States where the arc light has been installed has called forth a number of devices for placing incandescent lamps on arc circuits. This has heretofore been accomplished by the aid of what are termed "distributors," which practically are switches connecting the lamps in multiple series in the arc circuit. A decided departure has, however, recently been made in the method of operating incandescent and arc lamps on the same circuit, and for this purpose induction is called into play in a novel and ingenious manner. The inventor of this system, Mr. Philip Diehl, of Elizabeth, N.J., showed, at the Philadelphia Electrical Exhibition of 1884, an incandescent lamp which was raised to incandescence by the secondary current induced in a coil placed within the glass of the lamp itself, and which was acted upon by a current circulating in an exterior primary coil.

In the method of working employed at that time Mr. Diehl used an alternating current machine to produce the variations necessary in the primary coil. But it is evident that when continuous currents are employed, such as on the large majority of arc circuits, some device is required for varying the current in the primaries of the incandescent lamps, while at the same time the current in the arc lamps remains unchanged.

This problem has been ingeniously solved by Mr. Diehl in placing in the circuit an interrupter, and so connecting the incandescent lamps that they form independent paths for the main current, so that the latter is never actually broken in the arc lamp circuit. Thus, instead of employing alternating currents, he uses a continuous current, which is broken at a rapid rate.

The manner in which the lamps are connected in circuit will be readily understood from the diagram (Fig. 1). From the dynamo we will suppose that the current passes through two arc lamps B B and then arrives at a series of incandescent lamps to be lighted. The lamps, it will be noted, are grouped in two branches, series I I I and I′ I′ I′. At one side the branches are connected to the brushes *b b′*, which bear against the interrupter C; while at the other side they are united at F, and form the continuation of the circuit.

The circuit conductor is brought to the centre of the interrupter C, which is here shown as having three conducting segments *d d d*, all joined together, and three insulating segments

* From the *Electrical World* of New York.

iii. Now it will be noted that the brushes are so placed that at no time can brush *b* leave one of the conducting segments *d* before the other brush *b′* has made contact with one of the opposite conducting segments. But it will be seen that a slight revolution of the interrupter after both brushes make contact brings one of them on to an insulating strip *i*. The result is that the current will be interrupted in one of the branches I or I′, according to whether the brush *b* or *b′* is on an insulating strip of the interrupter. It will be observed, therefore, that the main current is never broken, but that it it is merely shifted alternately between the two branches of incandescent lamps I and I′.

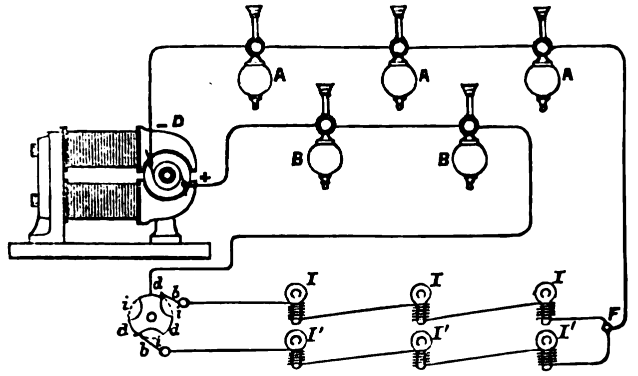

Fig. 1.

The rapid revolution of the interrupter creates the variations of current in the primary coil of the incandescent lamp which induces the requisite current in the secondary, within the lamp, to which the filament is attached.

With this short explanation of the mode of operation of the system, we come to the description of the apparatus employed in its installation. This embodies a number of ingenious and novel points.

It will be readily understood that at any one point an indefinite number of incandescent lamps may be placed in the circuit, and at each such point a current interrupter is placed. The entire apparatus is shown in the engraving, Fig. 2. It consists simply of a cylinder of brass, having a

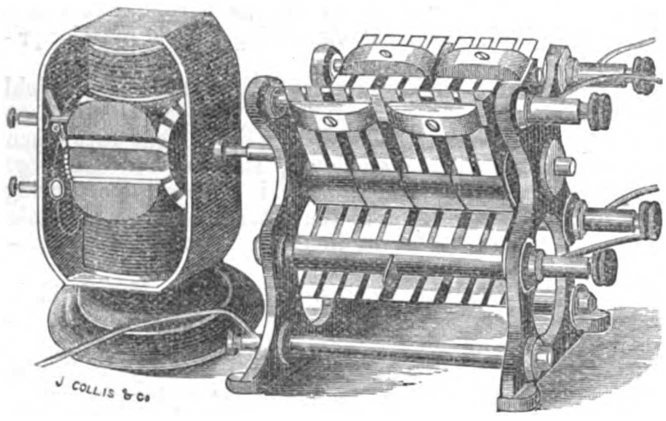

Fig. 2.

number of longitudinal grooves, which are filled with strips of glass that form the non-conducting segments of the interrupter. Four sets of brushes bear against the circumference of the cylinder, each two opposite pairs being connected so that in reality they form only a single pair of brushes. The object of the construction adopted is to secure a double length of contact without increasing the width of the brushes, and hence the length of the cylinder.

The principle of its working is the same as that shown in the diagram, Fig. 1. The interrupter is coupled direct to a small motor which drives the cylinder at a high speed, and thus effects several thousands of interruptions of the current per minute. The little motor is driven by the main current, and requires but very little power, not more than is absorbed by one or two incandescent lamps.

The lamp and the holder employed in the system are shown in section in Fig. 3.

The lamp, as will be seen, consists of a glass globe having a hollow cylindrical extension, and without any leading-in wires. Within the cylindrical portion there are wound a few layers of fine wire, S, to the ends of which the filament F is attached. The fine wire within the glass globe forms the secondary wire of the induction combination, the primary wire of which, P, is firmly held in the holder and enclosed within the case E. When inserted in the holder the lamp fits snugly within the primary coil and the secondary wire within the glass is brought in close proximity to the former.

As the inductive effects between the wires alone would be very feeble without the addition of iron to the combination, Mr. Diehl has added the latter, and at the same time disposed it so that the iron is made a regulator, by which the brilliancy or candle-power of the lamp can be changed at will. It will be seen that when the lamp is placed in its holder the hollow cylinder surrounds a core of soft iron wires I, and these are the means of intensifying the inductive action between the two coils. The bundle of iron wires is fixed to a rod, R, which can be pulled up or down, and by means of which any desired portion of the iron core can be withdrawn from the coils. This weakens their action correspondingly, and thus, by merely pulling down the rod R, the brilliancy of the lamp can be changed to any desired degree, even to a point at which the filament ceases to be incandescent. The arrangement is so contrived that when the rod is full down, the lamp primary coil is short-circuited, so that no current whatever passes through it.

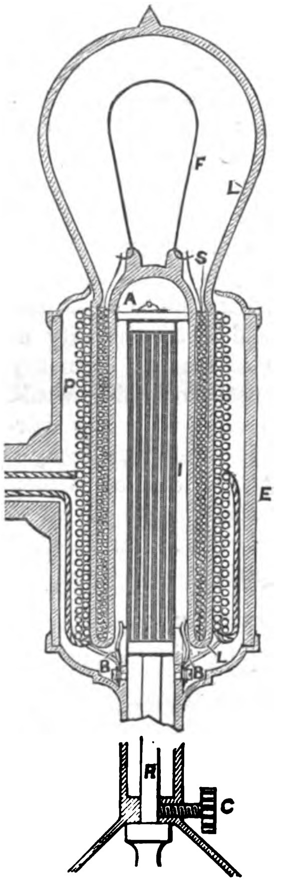

Fig. 3.

The manner in which the latter function is effected will be readily understood. It will be seen that two spring fingers B B are connected respectively to the two ends of the primary coil, and are normally out of contact. The top of the iron core carries an insulated copper washer, A. Now, when the rod is pulled full down, the washer A strikes both springs, forming a connection between them, and thus short-circuiting the primary coil, so that practically no current passes through it, and hence the lamp consumes no power. If desired, of course, any ordinary cut-out can be applied to the lamp to extinguish it.

With this system it is evident that lamps of varying candle-power can be placed indiscriminately in the incandescent branch circuits, since their brilliancy depends only upon the construction and relative proportions of the primary and secondary coils. Mr. Diehl finds that a lamp having 90 ohms resistance and giving about 16 candle-power will work well with only ¼ ounce, or 50ft., of No. 29 copper wire in two layers, placed as the secondary within the lamp. The copper wire employed is bare, and the layers are wound upon, and separated by, a thin sheet of mica.

These induction lamps work equally as well on alternating currents and from 7,000 to 10,000 alternations or breaks per minute, and are found to give the best results. Where the lamps are employed on incandescent circuits alone Mr. Diehl prefers to use the alternating current.

The lamp we have described is the latest form adopted by the inventor, but he has also devised several others, among

which is one in which the lamp encloses a Siemens shuttle-wound armature, which is placed within the field of a horse-shoe electro-magnet. Thus, by turning the lamp and included armature so that the poles of the latter face the poles of the magnet, the lamp lights up, while when placed at right angles to that position the lamp becomes dim.

MAXWELL'S THEORY OF ELECTRICITY.

(Concluded from page 313.)

Let us now consider a wire traversed by a current and placed in a field of magnetic force perpendicularly to the lines of force S N (Fig. 1), and suppose the current C C′ to travel away from the reader. It is easy, after what has been already said, to picture the molecular (or cellular) rotations due to the magnetic field (circle A) and to the current in the wire (circles B and B[1]). We now see from the figure that the current whirls above the wire rotate in the same sense as those of the field, while in those below the wire the rotation proceeds in the contrary sense. The first set therefore produce an additive effect and the latter a differential effect. The angular velocity ought then to be less underneath than above the wire, and therefore the wire will be submitted to a force apparently directed from above perpendicularly downwards. The dotted circles show the planes of the rings formed by the whirls, one belonging to the field and the other to the current.

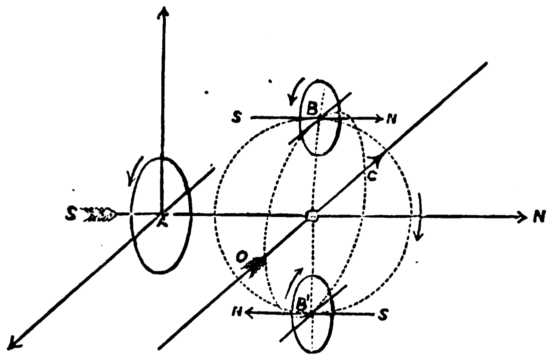

Fig. 1.

In the same way, consider next, two parallel wires traversed by currents C C in the same sense (Fig. 2). The rotations due to each of them are in the contrary sense for the space between the two wires, while they are in the same sense in the exterior space; the effect is therefore an apparent attraction, tending to cause a movement of approach. The figure explains itself. We thus account for each of the laws of Ampère.

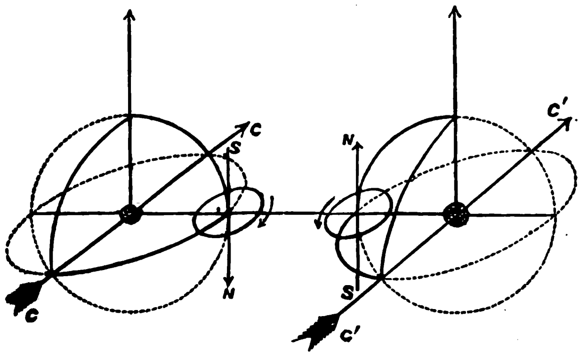

Fig. 2.

Induced Currents and the Law of Lenz.—Assume that a current commences to flow through a given wire; the displacement of the electric particles impresses a movement of rotation upon the neighbouring cells, and we have already seen that this sets up a series of annular whirls of progressively increasing velocity as we travel towards the circumference of the conductor. At the boundary of the dielectric the mechanism of transmission is modified, because the particles are no longer susceptible of a movement of translation, save to a very slight extent; they can, however, still rotate upon their axes, and thus continue to propagate the whirling movement of the cells. But suppose now that the perturbation of the dielectric reaches the boundary of a second conductor. The particles of electricity in this wire will be acted on in the same way as those in the dielectric, but meeting with very little resistance to their motion along the wire, they find it easier to move through the wire than at once to transmit the vortex motion to the elastic bodies on the other side of them. But when a driver and a follower are connected by a differential wheel, if the follower be retarded only by its own inertia, however small a resistance the differential wheel may experience to its motion of translation, it will at length cause the follower to turn at the same rate as the driver, and its motion of translation will then cease. Hence the resistance of the conductor at length brings the electric particles to rest, and causes them to communicate the vortex motion to cells beyond them. Thus, when a current is started in a wire transitory currents in the opposite direction will be induced in neighbouring conductors, while electric stress will be produced in the dielectric, the elastic cells whose motion constitutes the molecular whirls being at first deformed by the tangential stress of the electric particles; but both the induced currents and the stress will have entirely ceased so soon as all the molecular vortices are in full swing. The electro-magnetic induction is thus propagated beyond the conductor, although the induced current is only of brief duration.

When an electromotive force is applied to a wire, the current does not acquire its permanent state until the whirls not only in the wire itself, but also those in the surrounding mediums, have themselves acquired their own permanent state, and to establish this condition requires the expenditure of a certain amount of work; from which is is evidently impossible for any finite electromotive force to give rise instantaneously to a finite current. There must then exist a reaction of inertia, having the same effect as inverse electromotive force; this is known as the *electromotive force of self-induction.* This reaction will be so much the more powerful, as more energy is required to develop the whirls in the surrounding medium.. It depends, then, upon the nature of this medium—upon its *density,* which Maxwell has assimilated to magnetic permeability. Thus, it is because of the very great density of the medium in iron that the self-induction of a coil is so largely augmented by a core of this metal.

Lastly, if after the current has been established in a wire the circuit be broken, things cannot return to their normal condition until the kinetic energy of the whirl of the dielectric has been expended. But since we have attributed a perfect mechanical adjustment to the elements of the medium no work is done in maintaining their motion; and the energy originally imparted is therefore expended in the conductors in the field in displacing their electric particles. But if the translation of the particles of the conductor has impressed a movement of rotation in a certain sense upon the cells of the dieletric, it is clear that if this movement continues after the withdrawal of the electromotive force, it ought to maintain the motion of the particles in their original direction. The conductor will therefore be traversed by an *extra current,* and any neighbouring conductors by induced currents, in the same sense as the primitive current.

Let us now suppose that in a magnetic field a conductor perpendicular to the lines of force is displaced in such a manner as to cut the latter at right angles. We should expect that in front of the moving wire the lines of force or threads of vortices would be squeezed together transverely, but extended in the direction of their length, somewhat in the same way as elastic strings would be affected by the wire before they broke and allowed it to pass through. Behind the wire the lateral pressure will be relieved, the vortices will contract in the direction of their axes and expand equatorially. This is illustrated in Fig. 3. But we have seen that the effect of stretching a rotating elastic in the direction of its axis of rotation, and compressing it at right angles to this direction, increases the velocity of rotation, so that the actual velocity of every point on the surface is increased; while the contraction of the body along the axis of rotation diminishes the velocity. Hence, as long as the wire is moving

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across the lines of force the velocity of the whirls in front of the wire will be greater than that of the whirls behind, and the electric particles of the conductor situated thus among whirls of unequal velocities receive a tangential impulse in the sense of the more rapid rotation, and a current is therefore set up. But this current is evidently directed in such a sense that its reaction tends to accelerate the rotation of the whirls in front, and to retard those in its rear, which in consequence determines upon the wire an electro-magnetic pressure from the front to the rear. The sense of the current induced is then such as to *oppose* the movement of the conductor. Thus the laws of Faraday and of Lenz follow as a consequence of our hypothesis.

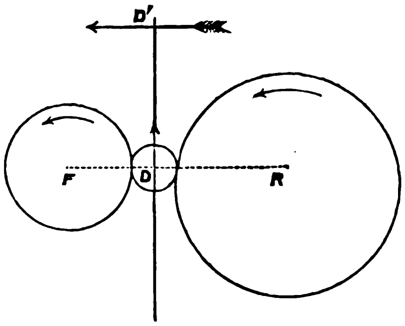

Fig. 3.

Electrostatic Phenomena.—If, within a certain space, electricity is *displaced* in a certain sense, the particles, although exercising a tangential effort upon the contiguous cells, cannot make them turn, because these efforts are equal and similarly directed at the two extremities of each diameter. There results, in this case, only a pressure upon the cells and an elastic deformation of the medium, which is transmitted step by step by the electric particles, as by an incompressible fluid; this constitutes electrostatic induction. As soon as the force which set up the original displacement ceases to act the elasticity of the deformed medium comes into play and restores each particle to its initial place, and the energy accumulated is expended in the *discharge.* The difference between this *electric displacement* and a current is that here the particles of electricity cannot move far from their initial position; following the analogy of Maxwell, a conductor resembles a *porous* membrane which opposes more or less resistance to the passage of a liquid, while a dielectric is like an elastic membrane, which, though impermeable to the liquid itself, yet transmits its pressure.

Thus all around a charged conductor in the direction of the electric displacement the cells of the dielectric are submitted to a compression which decreases with the square of the distance from the conductor, because the surface over which it is spread increases in that proportion; in the transverse direction there is, on the contrary, a dilatation of the cells. We shall therefore have the same appearances of attraction and repulsion between electrified bodies as we have already determined and accounted for between magnetic poles.

The Ratio of the Electrostatic Unit of Quantity to that of the Electro-Magnetic Unit is Equal to the Velocity of Light.—Let us consider two conductors having equal charges and of the same nature; the repulsion between them is then proportional to the elasticity of the medium which separates them, and to the square of their charge. If, then, we change the nature of the medium—that is to say, its elasticity—in order to maintain the same value for the mechanical effort between them, we must at the same time vary the value of their charges in the inverse ratio of the square root of the elasticity. It is only after specifying the medium in which we operate that we can assign a definite value to the electrostatic unit of electricity; that is, to the quantity which at unit distance, repels an equal quantity with unit force. If we change the medium, the unit thus defined varies in absolute value inversely with the relative value of the square root of the elasticity of the new medium.

But we can adopt another definition for the unit of electricity, based upon the law of Ampère instead of the law of Coulomb. We can say, the unit of electricity is the quantity conveyed in one second by a current which, when traversing a conductor placed at unit distance from a second conductor carrying an equal current, exercises upon the latter unit force. This is the *electromagnetic* unit of quantity. Here, again, intervenes the nature of the medium, for the lateral pressure due to a molecular whirl is proportional to the square of its velocity, and to the nature of the medium, otherwise the velocities are the same for equal currents. Then for different media, the electromagnetic unit of electricity varies inversely with the square roots of the densities.

For any substance whatever, the ratio of the electro-magnetic unit to the electro-static unit is therefore equal to the square root of the ratio of the elasticity to the density, in this substance, of the general medium which transmits electro-magnetic perturbations. But the formula which expresses this ratio is, in accordance with the established principles of mechanics, the same as that which expresses the velocity with which an undulatory movement of transverse vibrations is propagated in the medium. On the other hand, we have admitted, by our hypothesis, that the medium which is the vehicle of electro-magnetic perturbations is the same which serves to transmit the waves of light. Lastly, the theory of light requires that the vibration should be transverse to the direction of propagation of the wave. From all this it follows that for all dielectrics the velocity of light is represented by the ratio of the two units of electricity. We know that this theoretical conclusion has been very closely verified by experiment in the particular case of air.

The Specific Inductive Capacity is Equal to the Square Root of the Index of Refraction.—Two conductors having given charges, exercise upon one another at a given distance an action which varies inversely as the specific inductive capacity of the dielectric which separates them, and therefore proportionate, upon our theory, to the elasticity of the medium of propagation in the dielectric. The specific inductive capacity is then inversely as the elasticity of the medium. And also the density of the medium which is correlated with the magnetic permeability must be sensibly equal both for vacua and for the various dielectrics. From which it follows that, for these bodies, the specific inductive capacities are inversely as the squares of the relative velocities of light in these media; or, which comes to the same thing, that they are equal to the squares of the indices of refraction. But at this point a double difficulty presents itself; the value of the index of refraction varies with the nature of the radiation which we consider, and the processes by which we measure specific inductive capacity* involve a duration of charge enormously greater than that of the period of one vibration of light. We cannot, therefore, expect to obtain precise numerical accord between the results of the two orders of experiments, and Maxwell himself only enunciated the law as strictly applicable to the limiting case when the indices of refraction are taken for an infinite wave length.

Numerous experiments have been carried out in order to obtain confirmation of these theoretical deductions, and although the exceptional difficulties which are met with in this description of research have sometimes led to apparent failure, we are nevertheless able to perceive that the discrepancies are not of any importance, at least for those bodies which play a well-defined part as dielectrics.

Conductors are Opaque.—We have already observed that by the nature of the connecting mechanism, the movement of rotation of the cells is effected in dielectrics without consuming energy, and it follows that the movement may be propagated to infinity—these media are therefore transparent. But in conductors, in place of a mere transmission of a motion of rotation, the electric particles are set in motion in opposition to the frictional resistance of the neighbouring cells, and as nothing in the mechanism tends to restore them to their original positions, the electro-magnetic perturbation gradually loses its energy in the form of heat. Bodies which thus intercept the electro-magnetic perturbations ought, therefore, to be opaque to light.

* It is well known that specific inductive capacity is a function of the duration of charge.

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But while true in a general sense, this conclusion also offers very serious difficulties to experimental verification*—perhaps for the same reason of the slowness of our measurements as upsets our calculations of specific inductive capacity.

Magnetic Rotation of the Plane of Polarisation.—In the last place, if we seek, by the aid of this theory, to determine the action upon a ray of polarised light which traverses a magnetic field in the direction of the lines of force, we arrive at the result experimentally obtained by Faraday, and are enabled to enunciate a law which shows that the magnetic rotation will be proportional (1) to the refractive index, for the particular light employed; (2) inversely to the square of the length of the wave in air; (3) to the thickness of the refracting substance; (4) to the density of the medium of propagation in this substance—that is to say, to its magnetic permeability; (5) to the velocity of rotation of the whirls—that is to say, to the component of the magnetic force in the direction of the ray of light; (6) to the mean diameter of the whirls.

The theory lends itself with equal readiness to the explanation of the phenomena of diamagnetism, under the condition that in diamagnetic bodies the whirls take place in the inverse sense to those of magnetic substances.

At this point we must close our summary. It would scarcely be easy to carry it further without resorting to mathematical expressions, and this is not our present intention. But before concluding we would insist upon one point, and that not the least essential. However useful we may find these ideas to be, and whatever ultimate signification we may accord to the wonderful conception of Maxwell, we must remember that for the present these intangible cells, and particles, and whirls serve only as a bridge intervening between the known laws of mechanics and the experimental facts of electricity; they do not themselves appear in the final equations. The results obtained by their assistance are, and remain, independent of their actual existence, and are, indeed, identified with the known facts of nature. All the scaffolding of our speculations may perhaps turn out to have no place in the ultimate structure, but it has at least served to bring us to the same level.

* Gold, for instance, as Maxwell himself remarks, though one of the best conductors, is distinctly transparent when in the form of excessively thin leaf.

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the late meeting of the British Association on various subjects connected with Electrolysis :—

THE VERIFICATION OF FARADAY'S LAW OF ELECTROLYSIS WITH REFERENCE TO SILVER AND COPPER.

BY W. N. SHAW, M.A.

Since the time of Faraday his law of electrolysis has not been subjected to any very extensive experimental investigations. A summary of the results obtained is given in the article on Electrolysis in the "Encyclopædia Britannica." The most accurate verification appears to have been conducted by Soret, who attributes to the law an accuracy of 0·2 per cent. for copper and silver. Buff used different currents, and found the law verified by experiment to about 1 per cent., but the general impression has been that the law was only true to a somewhat rough approximation.

A practical acquaintance with the behaviour of an electrolytic cell of copper sulphate shows that it is not *necessary* to attribute the defect from the theoretical value of the chemical equivalent obtained in that way to the failure of Faraday's law. In depositing copper upon a copper plate it may often be observed that small but brilliant red crystals are formed on the deposit. These crystals under the microscope are very beautiful; they may probably be regarded as a suboxide of copper formed by the action of the copper on the solution. A purple coloration is, moreover, often formed on the cathode, and this is possibly due to the presence of the same compound of copper. This secondary action produces, of course, a difference in the weight of the deposit formed, and the true amount of electricity which has passed cannot be inferred either from the weight of the copper with the compound or from the weight of copper remaining when the crystals have been removed.

Further, it is well known that a copper plate when immersed in a solution of copper sulphate without any current gives rise to some chemical action which causes the copper plate to alter in weight. The alteration may be either in the direction of increase or of decrease of the weight, the effect depending upon the state of the plate and the state of the solution.

In considering the increase in weight of a copper cathode in an electrolytic cell we cannot without definite experimental reasons neglect to consider the possibility of both these actions occurring together, and, moreover, the passage of the current may produce complicated results which cannot be inferred from the action of the solution in the cell under other conditions. Dr. Gore has made very numerous experiments upon this subject, without, however, arriving at any very satisfactory result.

In view of the importance of the subject, a very large number of experiments have been made at the Cavendish Laboratory at Cambridge under my direction during the past two years. They may be divided into two groups. (A). Experiments to ascertain whether two copper cells give the same amount of deposit for the same current; and (B) experiments to determine whether a copper cell can be arranged so that, on comparison with a silver cell, within sufficiently wide limits of current it will give a value of the chemical equivalent of copper agreeing with that obtained by chemical methods.

A.—Experiments on Copper Cells Only.

These experiments consisted in arranging pairs of copper cells with various electrodes, as copper plates, copper wires, copper cylinders having wire connections, platinum wires, in order to ascertain whether the disturbing actions were limited to the surface. The results were very irregular and disappointing. Errors amounting frequently to more than 1 per cent. occurred without any assignable cause.

The same is all that can be said about experiments with different solutions of sulphate, including solutions from which air had been expelled by boiling, the experiments being then conducted under the receiver of an air pump. Endeavours to allow for the differences of the cathode weighings by supplementary experiments on the effect of the solution upon plates not connected with the electrodes have likewise proved fruitless. The enumeration of these experiments would serve no practical purpose, as they lead to no generalisation; I shall therefore pass over them.

B.—Experiments on the Comparison of Silver and Copper Cells.

One of the most disagreeable features of the experiments referred to in the preceding section was that when two cells were compared, and a difference in the increase of weight of the cathodes was obtained, it was impossible to say whether either or both of the two cells was at fault, and it was therefore decided to employ a silver cell as a standard. Lord Rayleigh was at the time engaged on his experiments upon absolute value of the electro-chemical equivalent of silver, and had not yet arrived at a result. Experiments were therefore made to obtain a silver cell that might be fairly regarded as a standard. The only difficulty in the way was that the deposit of silver from pure nitrate is crystalline and very rough. The deposit was taken upon a platinum crucible, and it was feared that error might arise, either from mechanical loss of the silver during the operation of drying, or from the retention by the deposit of water, or salt in solution. Attempts were therefore made to use as electrolyte (1) a solution of chloride of silver in hypo-sulphite of silver, (2) a solution of nitrate of silver containing glycerine, (3), a solution of nitrate of silver containing acetate of silver. The deposits obtained with all these are much closer and harder, but the hyposulphite solution is very unstable, and a current beyond a certain density precipitates a black sulphide which destroys the experiment. The other solutions were also discarded after consultation with Lord Rayleigh, who had then shown that a 15 per cent. solution of pure nitrate gave a perfectly satisfactory silver cell if proper precautions were taken with the drying, whereas the solutions containing organic salts were liable to serious error, probably in consequence of the inclusion of the solution in the pores of the deposit.

It was originally intended to use only those experiments from which the loss of the anode was obtained equal to the gain of the cathode. It was found, however, that the possibility of weighing the loss of the anode was simply fortuitous, the action of the solution upon the silver always producing a sort of honeycomb formation, and ultimately leaving smaller particles which fell off in washing. This was the case even when a silver crucible was used as the anode. It was therefore decided to use the gain of the cathode only. The form of silver cell adopted is that of Poggendorff's voltameter, in which a platinum crucible standing on a copper plate is the cathode and a silver rod the anode. The crucibles were about 1½in. in diameter and 2in. high, and the silver rod forming the anode was about half an inch in diameter.

The method of drying the deposit was to wash in distilled water by filling up the crucible several times, and allowing it to stand for some time, then, after thoroughly rinsing, to wash it out with alcohol and dry in a hot air bath at about 260° C.

As the crucibles were very different in size from those used by Lord Rayleigh some experiments were made to determine their behaviour.

The results are shown in Comparisons (A) (B) (C) (D) in next column.

The chlorate deposit after being heated to redness was dissolved in pure nitric acid and the solution tested for chloride, but none was found.

The silver cell being thus shown to be capable of working quite satisfactorily, the arrangement and comparison of copper cells were proceeded with. It was found in the previous experiments on copper that the deposits obtained on platinum wires gave much more concordant results than any other form of cell. This form of cell had been already used by Soret. It was accordingly decided to adopt that form. The cathodes were platinum wires about 15cm. long and 1mm. in diameter, and the anodes were wires of electrolytic copper whose diameter was somewhat greater. It is, however, well known that the density of the solution alters very considerably in the neighbourhood of the cathode, and if the electrodes are vertical this effect is not so much interfered with by convection currents as when the electrodes are horizontal. The wires were therefore placed horizontally in the solution; for this purpose they were bent at right angles, and the one end fastened to a binding screw attached to a thick wooden rod that lay on the edges of a porcelain dish that contained the electrolyte. A number of cells were prepared respectively for 1, 2, 3 . . . . . . up to

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Comparison (A) *of Two Crucibles of Different Sizes.*

Date.	Time in minutes.	Current in amperes.	Large crucible grammes.	Small crucible grammes.	Difference.
Feb. 6	100	·3096	2·0789	2·0802	− ·0013
„ 7	120	·3638	2·9312	2·9364	− ·0052

Comparison (B) *of an Old and New Crucible.*

Date.	Time in minutes.	Current in amperes.	Old crucible.	New crucible.	Difference.
Feb. 11	120	·4677	2·5203	2·5183	·0020

Comparison (C) *of Cell with Acetate with one Without.*

Date.	Time in minutes.	Current in amperes.	Crucible with no acetate.	Crucible with acetate.	Difference.
Feb. 13	123	·3084	2·5391	2·5467	+ ·0076
„ 14	120	·3521	2·8251	2·8368	+ ·0117
„ 16	125	·4047	3·3850	3·4016	+ ·0166 The crucibles were made red-hot and re-weighed
„ 18			3·3850	3·3966	+ ·0116
„ 18	120	·3416	3·0610	3·0777	+ ·0167 Heated and re-weighed
„ 19			3·0609	3·0685	+ ·0076
„ 19	120	·2794	2·2429	2·2512	+ ·0103
„ 22	120	·4510	3·2261	3·2473	+ ·0212 Heated and re-weighed
„ 23			3·2258	3·2431	+ ·0173
„ 23			2·9957	3·0114	+ ·1183

Comparison (D) *of Pure Nitrate Cell with Chlorate Cell.*

Date.			Chlorate Cell.	Nitrate Cell.	Difference.
May 14			2·0904	2·0895	·0009
			(heated to redness and re-weighed).		
„ 15			2·0902	2·0891	·0011
June 5	120 min.	·3093	2·2270	2·2271	·0001
„ 7	130	·2852	2·4901	2·4900	·0001

16 wires. The wires were arranged about two inches apart, and between them lay the anode wires attached to a similar piece of wood that rested on the other end of the dish; the wires in the same cell were put in multiple arc by a strip of copper laid along the wood, through which the binding screws passed. Some difficulty was met with in arranging that the anodes and cathodes did not touch, but with care it was surmounted. The solution was an approximately saturated solution of Hopkin and Williams' pure copper sulphate. No acid was added. The wires with their deposits were washed by rinsing them in several changes of distilled water and then dipped in alcohol and dried in an air-bath at a temperature of about 100° C.

In the experiments given below the copper deposits were brilliantly clean and generally showed no trace of oxidation on drying. The reason for this was never made clear; it is, however, easily recognised that under certain circumstances, defined perhaps by current density or the state of the solution, the copper deposits do not easily oxidise on drying, whereas in other experiments it seems almost impossible to dry them without considerable oxidation.

In all the experiments a rough tangent galvanometer was included in the circuit, so that any considerable variations of the current might be detected. A water or dilute copper sulphate cell, with copper electrodes whose distance apart could be adjusted, was also included to serve the purpose of a rheostat.

In a first series of experiments a silver cell was compared with each one of the copper wire cells in turn; the results are given in the following table:—

Table I.—*Comparison of Amounts of Silver and Copper Deposits.*

Date.	Time in min.	No. of wires.	Cu. deposit.	Ag. deposit.	Ratio.	Current in amperes.
June 10	145	1	·7309	2·4848	3·400	·2553
„ 11	120	2	·9268	3·1445	3·393	·3903
„ 11	120	3	·7651	2·5967	3·394	·3222
„ 12	115	4	1·0384	3·5130	3·383	·4549
July 7	120	2	·8417	2·8571	3·394	·3546
„ 7	120	1	·9245	3·1401	3·397	·3897
„ 8	120	3	·9764	3·3186	3·399	·3954
„ 8	—	4	·9740	3·3137	3·402	—
„ 8	120	5	·4206	1·4332	3·408	·1778
„ 9	120	6	·9969	3·3872	3·398	·4203
„ 9	—	7	·9482	3·2297	3·406	—
„ 10	120	8	·9471	3·2268	3·407	·4004
„ 10	120	9	1·1369	3·8721	3·406	·4806
„ 11	123	10	1·1261	3·8333	3·408	·4648
„ 11	123	11	1·0792	3·6783	3·408	·4454
„ 14	125	12	1·0416	3·5610	3·419	·4248
„ 14	128	1	·7318	2·4876	3·399	·2895
„ 17	125	2	·7577	2·5770	3·401	·3071
				Mean	3·4010	

It will be seen that the extreme error of the values from the mean amounts to rather less than ½ per cent.; the errors are irregular, but the difficulty of keeping the current constant was very great, and in some cases there was considerable difference, so that no inferences as to the effect of current density could be drawn. The arrangement was therefore altered, and five copper cells containing respectively 1, 2, 4, 8, and 16 wires, were all included in the same circuit with one silver cell. The electromotive force was obtained from 12 storage cells, or from Grove's cells. The observations are included in the first part of Table II. There was still some difficulty in keeping the current constant, and the apparatus was in consequence transferred to Emmanuel College, where a dynamo working at 110 volts for electric lighting was available; a satisfactory series of observations was obtained, shown in the latter part of Table II.

Table II.—*I. At the Cavendish Laboratory.*

—			Ratio of weight of silver to weight of copper.					—	
Date.	Time in min.	Weight of silver in grmms.	For 1 wire.	For 2 wires.	For 4 wires.	For 8 wires.	For 16 wires.	Current in amps.	Remarks.
Oct. 10	130	·9717	3·407	3·414	3·417	3·416	3·419	·1113	Galvanometer deflection variable. In the 4-wire cell 3 wires only received deposit.
„ 20	300	2·7019	3·401	3·408	3·409	3·420	3·447	·1341	Galvanometer deflection variable. In the 4-wire cell 3 wires only received deposits.
„ 26	170	3·3682	8·393	3·398	3·397	3·401	3·407	·2951	Galvanometer deflection variable. "One wire" slightly discoloured.
„ 29	120	2·8930	3·397	3·398	3·400	—	3·414	·3591	—
			II. At Emmanuel College.						
Nov. 27	120	3·9089	3·401	3·404	3·405	—	—	·5229	—
Dec. 10	110*	3·0259	3·413	-	—	3·411	3·408	·4093	Copper left in hot chamber too long, and was discoloured.
„ 15	120	4·9954	3·397	3·399	3·400	3·402	3·408	·6202	—
„ 16	130	4·0393	3·398	3·401	3·400	3·403	3·398	·4629	—
„ 17	120	4·0895	deposit loose.	3·398	3·393	3·403	3·406	·5076	—
„ 18	120	5·1570	—	3·400	3·399	contact	3·400	·6399	A copper crucible in the same circuit gave 3·407.

* Discarded.

Discussion of the Observations.

The numbers quoted in the table give the ratios of the amounts of silver to the corresponding amounts of copper deposited to the 4th significant figure. The balance used was a triangular beam Oertling, which could be relied upon for an accuracy reaching 0·1 mgm. The copper deposits generally amounted to about 1 gramme, and the accuracy of the weighings (corrected when necessary for the differences in the buoyancy of the air at the times of the initial and final determination of the weights) may be assigned as ·01 per cent. for copper deposits, and ·003 per cent. for silver. The numbers in the table are carried to one place less than the weighings permit. This is done intentionally in order to enable the reader to obtain a better general idea of the whole series of observations. It is easily seen that the differences in the table are real differences, and correspond to some real characteristic of the electrolytic action in the cells. A glance at the sets of observations belonging to the same experiment is sufficient to suggest a diminution of the amount of copper deposited as the current-density diminishes. The area of each wire was about 5 square centimetres, so that the current-density varies for the observations in Table II. between ·001 and ·15 ampere per square centimetre, and practically includes all current densities that can come under observation with this form of cell. In some cases the density was so great in the "one-wire cell" that the copper deposit was flocculent, and could not be weighed in consequence; and in some of the sixteen wires the deposit was not sufficient to cover the wires, but occurred in patches with small groups of copper masses.

If we proceed, on the assumption of the accuracy of Faraday's law, to attempt to explain the observed differences, we must first look to the action of the solution upon the deposit, since it is known that such an action actually takes place when copper is immersed in a solution of sulphate, and that the weight of copper might be reduced by solution. This action is said to depend upon the solution and the temperature. These considerations make it difficult to infer the action in the cell from that upon a wire without a current flowing; for, in the first place, the solution is weakened in the immediate neighbourhood of the cathode by the electrolysis; and, in the second place, the temperature is altered by the current itself, and was sensibly different in the different cells in some of the experiments; but to measure the temperature and allow for it is not very practicable, as it is not uniform throughout the cell.

Further, there may possibly be a division of the current between the salt and the solvent, and any action of the kind would probably have an effect upon the action of the solution on the cathode.

The only plan that has suggested itself to me is to arrange the observations in the order of current-density, and to see if any correction could be applied that would make the observations fairly comparable. This may fairly be applied, since the disturbing causes I have mentioned depend upon the current-density.

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In order to put this to the test, I have assumed in the first place that the action upon the deposit may be represented by an expression of the same form as would be required to represent the action of the solvent upon a wire immersed in the solution without any current. This we may take to be (for the comparatively short times of the experiments) a case of solution going in at a constant rate, and proportional to the area exposed. Thus, if δ be the actual loss of copper in an experiment when the area exposed is A, and the time t, we shall take

$$\delta = kAt,$$

and shall investigate whether a constant value of k can be taken to bring the observations into agreement. It is easily seen that this is equivalent to $\frac{\delta}{c} = \frac{k'}{d}$ where c is the total amount of copper deposited during the experiment, and δ the current-density; and where k' is also constant, but numerically different from k. In words we may express this by saying that the fractional correction is inversely proportional to the current density.

LAW OF VARIATION OF THE DEPOSIT WITH CURRENT-DENSITY.

It is difficult to settle what value to assume for k'. If k' be a true constant, its value can of course be calculated from any pair of observed results; but the magnitude of possible experimental errors, in comparison with that of the quantity under consideration, makes it highly improbable that the results would be at all concordant. It will at any rate be well, in order to avoid a possible error in the weighing of the silver, to use observations belonging to the same experiment for determining the value of k'. I have determined the values of k' for several pairs of observations, taken somewhat at random, with the following results (Table III.):—

TABLE III.

Experiment.	Range of current-density.	k'
Oct. 10.	·0014 - ·023	·0C00052
,, 20.	·0017 - ·026	·000025
,, 26.	·0037 - ·015	·000014
,, 29.	·0045 - ·036	·000024
Dec. 15.	·0077 - ·0310	·000025
,, 16.	·0115 - ·092	·000017
,, 17.	·0063 - ·051	·000017

The values of k' thus obtained are not very concordant. It must, however, be remembered that it is difficult to assign with confidence a numerical value to the current-density, since the effective area of the copper surface may be practically very different from that of the platinum on which the copper is deposited. In the expectation that the action of the solution upon the copper when no current is flowing might help to decide which value of k' to take, the "one wire" and "sixteen wires" of October 20 were replaced in the solution, after the weighing was completed, and remained there for the time of duration of the experimtnt, viz., five hours. The "one wire" lost ·0008 gm., and the "sixteen wires," ·0110 gm. This gives a loss of ·0007 gm. per wire, and corresponds to a value of k' = ·000025. On November 27 a loose copper wire was left in each of the cells during the experiment; and the mean loss of each of the wires during the time was ·0003 gm., which corresponds to approximately the same value. It will therefore be well to see what effect the correction of the weighings on the hypothesis that k' = ·000025 would have upon the tabulated results. The correction may be introduced by adding ·00014 gm. to the weight of each wire immersed for each hour during which the experiment lasts. The following table shows the weights of copper as thus corrected (Table IV.):—

TABLE IV.

Date.	1 wire.	2 wires.	4 wires.	8 wires.	16 wires.	Mean.	Mean per centage.
Oct. 10..	·2855	·2853	·2853	·2869	·2889	·2864	0·4
,, 20..	·7952	·7942	·7941	·7957	·7949	·7948	0·06
,, 26..	·9932	·9922	·9931	·9934	·9950	·9934	0·06
,, 29..	·8519	·8516	·8520	—	·8518	·8518	0·02
Nov. 27.	1·1498	1·1490	1·1489	—	—	1·1492	0·04
Dec. 15..	1·4708	1·4700	1·4703	1·4704	1·4698	1·4703	0·02
,, 16..	1·1888	1·1882	1·1892	1·1894	1·1932	1·1898	0·11
,, 17..	—	1·2039	1·2043	1·2037	1·2048	1·2042	0·03
,, 18..	—	1·5172	1·5183	—	1·5215	1·5190	0·11

An examination of this table shows that, with some few exceptions, the results, as corrected, are very fairly concordant. That no value of k' could be found which would apply equally to all the observations is obvious from the discordance in the values of a k' tabulated above. A striking feature of the table is that the numbers under the heading of "2 wires" seem now to be the minimum values of the table; the "1 wire" values are all greater; and the numbers in the other columns are very rarely less, and then only by very small quantities. This shows that the correction applied is probably too large, though it is sometimes very successful. It is probable that the correction ought not to be applied when the current density is very great, as the difference between the "1 wire" and "2 wires" is increased by the correction, though not entirely due to it. This, as already pointed out, is probably *à priori*, since the more rapid deposition of copper would weaken the solution in the immediate neighbourhood of the cathode. The correction may, however, be fairly adopted for the smaller current densities. It appears on examination of the current densities that the exceptional cases do not arise when the current density is below ·02 ampere per square centimetre, so that the weights of copper deposited with currents of current density, less that ·02 ampere per square centimetre, may be corrected by multiplication by a factor $1 + \frac{k'}{d}$, where d is the current density, and k' a constant not differing much from ·00002.*

CHEMICAL EQUIVALENT OF COPPER.

We have now to compare the results obtained for the ratio of the chemical equivalent of silver to that of copper with those obtained by purely chemical methods, in order to ascertain whether or not Faraday's law is strictly applicable in the case of silver and copper. If we take the results given in Landolt and Börnstein's "Physikalisch-Chemische Tabellen," we find the atomic weight of silver given as 107 66 by Meyer, and 107 675 by Clarke, and the accuracy is stated as being within ·05; that of copper is quoted as 63·18 from Meyer, and 63·17 from Clarke, with a possible error of ± ·5. This would give a value for the ratio of the chemical equivalents of silver and copper equal to 3·4086; or, allowing the fullest margin for error, the value lies between 3·38 and 3·44; so that the values obtained by the deposition of silver and copper seem to be all within the limits of error thus assigned; and we cannot, therefore, test the accuracy of Faraday's law until the value of the chemical equivalent of copper can be assigned with greater accuracy than appears at present to be practicable. We may, however, notice that the value 3·4086 is that which would be obtained with comparatively very small current densities, and occupies a place in the middle of a continuous series, and there seems to be no reason in the electrolytic behaviour of the cells for accepting that value as indicating a limiting result. We may therefore fairly approach the question the other way, and, using the observations to calculate the chemical equivalent of copper by Faraday's law, consider the results which follow. If we assume, as we seem fairly entitled to do, that the differences of the weights for different current densities are due to the solution of the deposited copper, it follows (assuming Faraday's law) that we must get a nearer approximation to the true amount of copper equivalent to the amount of silver deposited the greater the current density. The value would be affected by the correction discussed above; but it has been already stated that it is unsafe to apply the correction, or, at any rate, to assign to the value that of k' assigned above. But the consideration of that correction serves us to this extent, viz., to show that for current densities above ·02 its value must be very small indeed, reaching, as a matter of fact, with the value of k = ·00002, to less than one milligramme per gramme. But in determining by Faraday's law as accurately as possible the chemical equivalent of copper from that of silver, the correction cannot be disregarded without sufficient reasons. Some reasons for that course have been given, but in order to test further whether or not the correction should be applied I have plotted the observations on sectional paper, taking as ordinates the ratios of copper to silver, and as abscissæ the reciprocals of current-densities. If the correction should be applied throughout, the grouping of the observations should show a straight line inclined to the axis of current-densities. I have adopted this method of combining the observations belonging to different experiments for this purpose, in preference to the arithmetical one of taking means, because the latter is liable to be seriously affected by a set of observations, each one of which is far from the mean in the same direction, but which does not extend throughout the whole range. In the estimation by eye of a mean result of plotted observations allowance can be made for the effect such observations produce, whereas they may give a false appearance of general law to a set of arithmetical means.

The observations included in the Table II. when plotted do not give any indication of the divergence of the mean ordinates from a straight line parallel to the axis of reciprocals of current-densities until the current-density is less than ·02, and the straight line passing through the "centre of gravity" of the group of observations for highest current-densities, and inclined to the axis with the angle given by the value k'=·000025, would leave all the rest of the observations except three on one side of it; but a very fair result is obtained if the value of k' be somewhat reduced, and the line be drawn at the corresponding less inclination through the point corresponding to the "centre of gravity" of observations about the current density ·02. If we must take a staight line inclined to the axis as representing the results, the one which must be selected has an inclination to the axis of about one-half that given by k' = ·000025, and even that leaves on one side of it nearly the whole group of observations whose current-densities have reciprocals between 50 and 30. Further, the values of the ratios obtained from the observations for current-densities above ·02 are remarkably close, except in two instances; in one the ratio is very high, with a high current-density, and differs widely from other observations at about the same current-density; the other is very low, and belongs to an experiment which gives a series of very low values; this has been rejected because the wire which gave it was marked in the note-book as discoloured, *i.e.*, oxidised, at the time of weighing.

In order, therefore, to obtain the value of the chemical equivalent by this method, I have taken all the values obtained for current-densities greater than ·025 ampere per square centimetre. They are included in the following table:—

* The values obtained by Lord Rayleigh with copper bowls (*Phil. Tr.* Pt. II. 1884, p. 458) are:—

Current density, about ·012; ratio of equivalent, 3·405
,, ,, ,, ·026; ,, ,, 3·408
,, ,, 3·404

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TABLE V.

Current densities.	Ratios observed.	Ratios with the correction ($k' = \cdot000012$)
·124	3·3968	3·3965
·104	3·4005	3·4001
·093	3·3984	3·3979
·072	3·3971	3·3965
·064	3·4004	3·3997
·062	3·3994	3·3987
·052	3·4035	3·4027
·051	3·3982	3·3974
·046	3·4009	3·4000
·036	3·3984	3·3972
·032	3·3990	3·3977
·031	3·3998	3·3984
·027	3·4014	3·3998
·026	3·4056	3·4040
·025	3·3982	3·3966
Mean	3·39983	3·39838
Mean error	·00175	·00151

I have included in the same table the values obtained when the correction for the current density ($k' = \cdot000012$) is introduced, in order that an opinion may be formed as to the magnitude of the difference produced. It will be seen that the amount of difference corresponds to an error in weighing of only 0·3 milligramme per gramme. I have given reasons for preferring the value as calculated without the introduction of this correction, and from the circumstance already pointed out, viz., that after the correction $k' = \cdot000025$ is introduced, the "2 wire" values are minima, it would seem likely that the deposit obtained with the highest current density may be too great in consequence of the operation of some action which is not accounted for. To decide this point requires measurements to a degree of accuracy beyond that reached in the present observations, so that we may set down the ratio of the chemical equivalent of silver to that of copper, as obtained by this method, as being

3·39983,

with a mean error of ± ·00175 in the observations.

THE ATOMIC WEIGHT OF COPPER.

It will be at once noticed that the value obtained for the ratio of the equivalent differs by only 17 parts in 300000 from the number 3·4000, and there is some indication that the observed value is too small; we may therefore accept the observations as showing the ratio to approach very nearly indeed to 3·4000. This gives for the ratio of the atomic weight of silver to that of copper the ratio of the whole numbers 17 : 10. If we take the atomic weight of silver as 107·66, the atomic weight of copper will be 63·333. This result gives some striking relations; it gives, in fact, for the atomic weight of silver the number $\frac{19 \times 17}{3}$, and for that of copper $\frac{19 \times 10}{3}$, and therefore gives both as one-third of whole numbers. The atomic weight of silver is one of the most accurately determined of all, and the number here assigned to copper is within the limits of error allowed by L. Meyer; so that these remarkable relations may perhaps offer some reason for considering the value of the atomic weight of copper as deduced from Faraday's law as being worthy of consideration.

A number of speculations are suggested by the relations between the numbers thus arrived at; but it is not necessary to discuss them here.

COMPANIES' MEETINGS.

India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The twenty-third ordinary general meeting of this Company was held at the Cannon-street Hotel on Tuesday, the 22nd inst., under the presidency of Mr. S. W. Silver.

The SECRETARY (Mr. Wm. J. Tyler) having read the notice convening the meeting, the report of the Directors was taken as read.

The CHAIRMAN: I have great pleasure in moving the adoption of the report, containing, as I believe it does, a correct and concise account of our operations for the past year. The result fully justifies the dividend which we recommend for your adoption, and this, I consider, is a matter for congratulation. We are engaged in a commercial concern, and those in the room who, like myself, are familiar with such transactions, are well aware of the hand-to-hand fight that it is to produce such a satisfactory result. In addition to this, we have had the raw material much adverse in price, and no proportionate return on the sales. Now, I will refer to the item of debentures. The £100,000 debentures bearing 6 per cent. have been paid off, and, at 4½ per cent., £200,000 have been issued. The additional capital has enabled us to reduce our liabilities substantially. Indeed, I only refer to the different loans in last year's accounts of more than £100,000. As regards the item of cables the operations during the year—as stated in our report—include the laying of 2,000 miles. This has been successfully carried out, considering the unusual number of separate landing places. The steamer "Buccaneer's" size and construction render her specially adapted to the inshore work of such an expedition as the West African. With reference to the electric light, that is a subject which is attracting a great deal of attention. In this room I may say for your satisfaction that we have lighted up our works on a large scale. The operation has proved a complete success. The large workshops have a better light at a lower cost. The workmen find the atmospheric conditions under which they have to work very much improved. They have better air to breathe, and a better temperature for working. Our vessels have been actively employed during a considerable portion of the year in the West Indian waters, and on the West Coast of Africa. As regards the works, they are in a complete and efficient condition, capable of undertaking at the shortest notice the most extensive contracts that we can secure. Now, in moving the adoption of the report and accounts, and that a dividend be paid, I think I should express in your name our thanks to the staff and the officials under our direction for their attention, and more especially to Mr. Matthew Gray and those with whom he has carried out the work on the West Coast and vicinity. I think I ought also to refer to the fact of this meeting having been delayed one week later than it need have been had not the expression of the shareholders' wishes on the last occasion been acted on. They desired to have fourteen days' notice, and we could have met a week ago but for that. I will now move "That the Directors' report and accounts now presented be received and adopted, and that a dividend of £1 per share, free of income-tax, payable on and after the 23rd inst., be now declared."

Mr. NEIL BANNATYNE seconded the motion.

Mr. SWEET said he desired to ask a question with reference to the income-tax. They were charged in the profit and loss account £4,100 for that item. He believed that income-tax was generally paid on the net profit of all companies, not on the gross profits; but the income-tax paid by this Company appeared to be on the gross, because their net profits were under £60,000, and 8d. in the £ on that would be just £2,000. If they paid on the gross they paid on all salaries as well, and the Government in that case got the tax paid twice over.

Mr. PAYNE asked whether, in these hard times, the Directors could take anything less than £4,000 a year for remuneration. He would not wish for a moment that they should reduce their fees against their wishes, but when times were so bad reductions had to be made all round. A little spontaneous movement on the Directors' side would be far better than any hostile resolution from the shareholders, and if the Directors saw their way to accept anything less he was sure it would be appreciated by the shareholders.

Mr. BIRD inquired what was the prospect of the sale of the works in France?

The CHAIRMAN, in reply, said that the income-tax was charged on the net profits, not on the gross.

The CHAIRMAN, in answer to Mr. Payne, said: I would say in the past we have gone through years when the shareholders had nothing, and when we took nothing, and that fact will be an assurance, or ought to be, that when the dividend is at a lower rate than 15 per cent. the point raised by Mr. Payne may be taken into consideration. In my remarks I also referred to the difficulty we have in making such a return as will enable us to pay you a dividend of 15 per cent.

Mr. PAYNE observed that the distribution was very satisfactory for all the original shareholders, but it was not so for those who had come in later.

The CHAIRMAN: As regards the French works, they are *in statu quo*. We have had no application with regard to them since the last meeting. He then put the motion in the usual way, and declared it carried. Continuing, he proposed the re-election of Mr. Abraham Scott, whose experience, he said, they found very valuable, and whose attention to his duties left nothing to be desired.

Mr. BANNATYNE seconded the motion, which was carried unanimously.

Mr. SCOTT thanked the shareholders for their confidence in him, which he said he would endeavour to justify.

Dr. SMALL then proposed the re-election of Mr. John Weise as auditor of the Company's accounts for the current year, at a fee of 30 guineas. They all knew that Mr. Weise had been for a considerable time auditor of the Company, and that he belonged to the firm, so well known in the City, of Turquand, Youngs and Co.

Mr. DIXEY seconded the motion, observing that the way in which Mr. Weise had audited the Company's accounts in the past year was a sufficient guarantee for the future.

The motion was carried unanimously.

Dr. SMALL said that before separating they were bound to pass a vote of thanks to the Directors for the able manner in which they had managed the affairs of the Company in the past year, giving the shareholders a dividend of 15 per cent., which was very good in these days. He had been down to the works, and he could endorse what the Chairman had said with regard to their efficiency. Mr. Silver had taken him over them, and he observed how efficiently they were carried on. He had pleasure in proposing a vote of thanks to the Directors and officials for their attention to the business, and thus obtaining a dividend of 15 per cent. for the shareholders for the last year.

Mr. TREBLE seconded the motion, which was carried.

The CHAIRMAN, in acknowledging the vote, assured them that if the Directors wanted an additional motive to apply themselves in a more determined way to the interests of the shareholders, it would be such remarks as Dr. Small had made. He begged to thank them in the name of his co-Directors and himself.

The proceedings then terminated.

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The Anglo-American Brush Electric Light Corporation (Limited).

The sixth ordinary general meeting of the shareholders in this Corporation was held at the Cannon-street Hotel yesterday (Thursday), under the presidency of the Right Hon. Lord Thurlow, F.R.S.

The SECRETARY (Mr. E. Garcke) read the notice convening the meeting, and the minutes of the last meeting having been confirmed, the report of the Directors (published in our last issue) and statement of accounts were taken as read.

The CHAIRMAN said that it gave him and his colleagues very great pleasure to have the opportunity of meeting the shareholders again to take counsel together. The circumstances of the past year had been especially anxious from very many points of view, and they had proved distinctly, if they had proved one thing more than another, that little, if any, general progress in electric lighting was possible until the unfortunate Act of 1882 was amended in the direction in which they desired. There was no use disguising the fact that the continued depression in trade had caused even less demand for electric lighting than had been the case in previous years. It was impossible, indeed, that any attempt at progress could be made until some future legislation had been passed on the subject. This was all the more to be regretted because in cases where enterprising manufacturers had had the courage to embark in electric lighting plant for the benefit of their workpeople and for the improvement of their works, the results had been eminently satisfactory, and he could produce a long list of names of distinguished firms who had introduced electric lighting even in the face of financial and other difficulties with which they were all familiar, and who did not regret or repent of their action in the matter. In most respects the volume of business had increased to a certain extent, though no doubt not to the extent to which they had every reason to anticipate it would. But he was sorry to say that that increase of business had not been followed by an increase, but by a decrease of profits. The reason for that was obvious. There had been a falling off in prices in electric lighting, as in other things. That circumstance had been mainly due to the very large increase of competing firms, who had been of two kinds. There had been distinguished firms that they could have no reason to complain of, such as Messrs. Crompton and Co., and many others whom he could name—firms who did honour to the industry, and whom the Company were always willing to meet on equal terms to compete against for honours in this industry. But they had also had to compete—and Messrs. Crompton and Co. had to share the same fate—against those cheap and unscrupulous contractors who called themselves electrical engineers, and gave themselves all sorts of scientific titles, and who came forward to execute great electric lighting works without even a knowledge of the rudiments of the science. Such men did electric lighting a great injury. They knocked down prices, and undertook to execute contracts not only at non-paying but at impossible rates. The result was that not being able to make any profit they fell back upon villanously scamping the work that they undertook. The shareholders must know how injuriously this system not only affected their interests but those of electric lighting as a science, because the public were naturally slow to discriminate, and, in most cases, it was impossible to discriminate between what was honest and what was dishonest competition, with the result that they saw in the leading journals letters from fire offices like the Phœnix and other great offices complaining bitterly of the dangers which were caused by electric lighting. The public in that way were prejudiced against it. They had heard at Chelmsford the other day the views of Mr. Crompton in connection with the price of electric lighting. Mr. Crompton was addressing an audience well able to appreciate what he said, and he told them that the selling price of dynamos during the last twelve months was little more than half—in some case not half—what they were selling for in 1885. He had also told them that he had not employed more than half the number of men that he did during the year 1885, and that a very large proportion of those whom he employed in 1885 were only working half time. Such facts as these spoke for themselves, and were perfectly incontrovertible. Let them take the Company's case. Their sales of dynamos in 1886 exceeded those of 1885 by 10 per cent., but the profits on those machines were reduced by 20 per cent. In incandescent lamps their sales had increased by 20 per cent. during the year, but the profits remained stationary as in 1885—that was to say they did a fifth more work for the same amount of profit. In the matter of carbons it was worse. The sales increased by 7 per cent. and the profits fell by 10 per cent. These figures, he thought, would explain more clearly than any words of his how those circumstances, absolutely beyond the control of the Directors, had forced them to appear before the shareholders on that occasion without offering them a dividend; but he could assure them that it was as much a matter of regret to the Board as it could possibly be to any of them. But they had one comfort, namely, that the figures he had given them meant that they had done more work, and that the electric light, despite the difficulties which he had alluded to, was undoubtedly gaining ground very slowly. There could be no question about that. They had, moreover, the painful consolation in coming before the shareholders without a dividend to offer that they were unfortunately in no singular position. They knew that the same misfortune had occurred to a great many other old-established undertakings, in other branches of business. Take, for instance, a company which was one of national importance—he meant the Cunard Company—one of the greatest companies ever established in this country. It had for many years paid 10, 15, and 17 per cent., but it had actually paid no dividend since 1834, although it had been in existence for 35 years, and for the first 30 of those years it made the boast—and the very proud boast—that it had never lost a letter or a life. Take, again, the Birkenhead Companies—the dock, railway, shipping companies, no matter what they might be—they had not paid a dividend since 1884. The same remark applied to the industries of Manchester, and the great iron and steel companies throughout the country. In fact it was no exaggeration to say that in purely industrial undertakings a dividend since 1884 had been the exception and not the rule. In their own case, he could assure the shareholders that it was not owing to any want of economy being exercised on the part of the Board and other officers that they were not able to pay a dividend, and they would find this statement to be perfectly correct by a comparison of the figures in the profit and loss account now with those of the corresponding period last year. Having entered into the details of profits and expenditure, he went on to say that, although their profit of £1,532 was a small one, it was on the right side, and they would carry it forward to swell, he hoped, the profit next year. Before going further, he ought, perhaps, to make some allusion to the figure at which their patents now stood in the balance-sheet. It would be found that they had been raised to the total sum of £53,085. When he had explained the circumstances under which they had been raised to that figure, he thought they would not regret the fact. He did not think they stood at 1s. more than they might fairly stand at, and it was a figure that might be sustained and maintained in the face of any cavilling. They must remember that the amount had been reduced since 1832 by no less than £179,466, and they had been practically written down since 1883 to £125,379. Now, he thought that considering that had been done in the course of four years, they might fairly present their balance-sheet without regarding themselves as being under the necessity of writing them down still further. In 1831 and 1882 they were aware that they received no less than £250,000 in cash, and £60,000 in shares from various sub-companies that were established. They had now completed the re-acquisition of the whole of the rights, and privileges, and licenses that were then sold to those sub-companies in Great Britain, with the exception of those of Hastings, Eastbourne, and Dublin, for £500 in cash, and about £12,000 in shares. Those figures were very remarkable, showing that they practically recovered for that small amount the property that they had sold in 1881-82 for £310,000 in cash and shares. It must be a satisfaction to the original shareholders—as it was to him, although he was not among the number, but as Chairman of this great Corporation—to know that at any rate a very substantial slice of that large sum of money found its way into the pockets of the original shareholders, and that this Company, notwithstanding all that might have been said against it, still retained the undoubted financial position of having paid during the five years that it had been established, an average dividend at the rate of 23½ per cent. to its original shareholders, who, at least, had nothing to complain of. They had the satisfaction of knowing that they began the year with a free hand all over Great Britain, and that they were not trammelled in their transactions with sub-companies. They were able to enter into contracts and negotiate for contracts in any one of the 52 counties in England and Wales. The same remark applied to Scotland and to Ireland, with the exception of Dublin. They also began the new year with their plant and machinery in decidedly an improved condition. They had all been thoroughly overhauled during the past year, and largely adapted to new features of their manufacture, and owing to that cause many departments had greatly avoided any depreciation whatever. Of course that would not apply to the whole of the plant and machinery, but he maintained that in many departments their machinery and plant were better adapted for what they had to do, and consequently were of greater value to the Company than they were a year or 18 months ago. He wished to say a few words on the character of the present business that they were carrying on. They had lately turned their attention very largely to ship lighting. That was a branch of lighting that had been enabled to go forward more steadily and with less interruption without amending the Act of 1882, and consequently it would be now found that almost all the ocean-going steamers of any magnitude—of the German Lloyd, the Peninsula and Oriental, the Cunard, and almost all other companies—were adopting, more or less, the electric light. Those who had crossed the ocean in steamers lit by electricity, and had had an opportunity of comparing the comfort in those steamers as compared with the past services, would be able to appreciate this fact; and it was no exaggeration to say that, whatever might be the fate of the electric light on shore, it was an ascertained certainty at sea. No ship in two or three years would be able to carry a single passenger which was not so illuminated. They had turned their attention for some time to try and secure contracts in that direction. They had had a good deal of success in obtaining orders from various of the great companies, and as they knew from the Government, and, as far as he knew, all the work that they had done had been eminently satisfactory, and would infallibly lead to a larger share of work of the kind. There was another branch of lighting which was destined to make very rapid progress he could not help thinking, and that was railway lighting. Train lighting had been taken up, as they knew, by a separate and a very powerful organisation, which undertook large contracts of that kind. But that organisation must get its machinery from somebody. The Company were doing all in their power to place themselves in a position by manufacturing the plant required for railway lighting by railway contractors, and he had no hesitation in foreshadowing that a very large volume of business from that source would fall into the hands of the Company in the near future. Then the exhibitions had done them a very good turn. They had recently had the good fortune (and he could not help attributing it to the satisfactory manner in which they had executed other works of the same description) to obtain the sole right of supplying the arc lighting to the Manchester Jubilee Exhibition, which would be the largest installation of arc lamps yet undertaken in Great Britain. They had already addressed themselves to the work, and there could be no doubt that they would be able to execute it in the most approved manner,

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and with the most recent improvements, and that they would give the same satisfaction there as they had done in Edinburgh, Liverpool, and elsewhere. There were other hopeful indications of great activity in electric lighting. It so happened that the early months of a year had proved in the past always the most satisfactory; but this year they compared very favourably with the preceding years, and he thought the shareholders would be pleased to hear that the orders that they had taken since the 1st of January were as nearly as possible equal to a third of the whole of the orders that they executed during 1886. Those included one for the lighting of two of the Peninsular and Oriental steamers. Hitherto that company had gone to other firms, but like the Admiralty they did not like to entrust all their work to one firm, but looked around for others, and accordingly they had made up their minds to give the Anglo-Brush Corporation a commission to light two of their ships. He had no doubt in his own mind that the way they would carry out the work would entitle them to anticipate to stand in the Peninsular and Oriental Company's books as contractors of the electric light for any future ships that they might build or refit. He would now briefly refer to the subjects of the special resolutions which they proposed to submit. The first two referred to paragraph 5 of the report, which referred to the purchase of the business of the International Electric Light Company. The negotiations were still in progress. Those negotiations required to undergo certain formalities in Austria and Hungary, as to registration and other things, before they could be finally carried out, and until the negotiations were accomplished it would be premature to say that their object had been effected. Subject to that proviso, they would acquire the old Anglo-Austria Brush Company (the present International), which would be of very great importance to this Company. There was no hesitation among the Directors as to the desirability of acquiring that business. It was only a question of terms. For a very long time the negotiations were protracted, which, under the circumstances, was only natural, but the figure that they had at last hit upon would be in the proportion of one £5 fully paid share of the Corporation for every twenty £4 paid shares of the International Company—terms which he thought would be satisfactory to both parties. These negotiations had been carried out mainly by Messrs. Cooper Bros. and Company, the auditors of the Company, and they thought, thanks to the efforts of that firm, that they were really acquiring a valuable property indeed. It was complicated with a share in a manufacturing business in Vienna—that of Messrs. Kremenezky, Mayer and Company—but they had gone into the subject of purchasing the interest in the firm, and had arrived at a figure in respect to it which might fairly entitle the Anglo-Brush Company's shareholders to regard the whole transaction with unmitigated satisfaction. The third resolution had reference to a power that they were seeking from the hands of the shareholders. The Board asked to be enabled to raise at any time that might be required a certain amount of fresh share capital to enable them to carry on any large works or other undertakings which might at any moment be entrusted to the Company. Of course what those works might be he was not at liberty to say, but he could mention one matter which had been very long pending and which he thought was always getting nearer a satisfactory conclusion—that was the question of the lighting of the City. They all knew that the authorities in this great City of London were eminently—and very properly he thought—a conservative body of men. They did not rush into a thing of the magnitude of lighting the large area of the City without due consideration of the vested interests entrusted to their charge, and there was one reason indeed why he was glad that those negotiations had been protracted, namely, that he felt that they occupied at the present moment a stronger position for dealing satisfactorily with that great matter, if they should have the good fortune to have a share of it entrusted to them, than they did a year ago. There was one point in connection with all City and town lighting that he desired to refer to, and that was the preferential position in which the Corporation stood in regard to what was known as the Callender-Webber patents, which he thought would prove of immense value to the Corporation, not only in the City of London, but in all large towns like Birmingham and Liverpool. He then referred to the Bills bearing upon the electric light which had been introduced into the House of Lords by Lord Rayleigh, Viscount Bury, and himself, and to the Government measure which is to be brought up for discussion this session, and which is a combination of the principal clauses of the whole three, and went on to say that he hoped that the latter would become law this Session, eliminating, as they all trusted it would do, the bad features of the Act of 1882. He would willingly withdraw his own Bill if the Government would only take up the question in a fair and liberal spirit for all parties concerned. His only desire was to see a Bill passed into law which would do justice to one of the most beneficent and really beautiful inventions that this century had produced. He concluded by formally moving the adoption of the reports and accounts.

The VICE-CHAIRMAN (Mr. J. S. Sellon) seconded the motion, and said that there was one point on which, with the permission of the meeting, he would like to say a few words. A certain degree of uneasiness had been created in the minds of the shareholders as to their incandescent lamps—which had been described by Mr. J. S. Forbes at a meeting a few days ago as "the key of the position"—by the recent decision in the Law Courts in the case of Edison and Swan *v.* Woodhouse and Rawson, lest that important branch of their manufacture should be seriously jeopardised by the judgment of the Courts. But he would wish them to keep quite tranquil on that account, for if—as the Chairman of the Edison and Swan Company had said—that company held the key of the position, the Anglo-Brush might claim to hold the master key. It was true that the aggressiveness of the Edison and Swan Company had, unfortunately, necessitated their entering upon costly proceedings for the defence of their rights, and though such expenditure was to be regretted, there was a satisfaction in knowing that thereby they rendered their position impregnable, and that their special processes of manufacture could not be interfered with, and that, despite the apparent momentary advantage which the Edison and Swan Company appeared to get in the Courts by securing judgment in the cases referred to, yet it was well known by many behind the scenes that much of the evidence given on their side would not bear the ordeal of critical examination; and though that given on the other side failed to substantiate many of the points involved, thus apparently justifying the judgment, yet in the light of their knowledge on the subject he regarded that judgment as indefensible. He was no believer in what was called "brag," but he was a believer in facts, and not only were they confident that they would be able by these facts to defend any assault that might be made upon them, but in the action which they had been obliged, in consequence of the procedure adopted by the Edison and Swan Company, to bring against that company, they had little doubt of being able to reverse the position which the Edison and Swan Company assumed, of placing the boot on the other leg. He would beg them, however, not to think for a moment that their resources would be needlessly wasted in any litigation. The policy of their directors had always been a conciliatory one—that was to say, that whilst doing their duty to safeguard their valuable interests, they had never attempted to harass other manufacturers engaged in the great business of electric lighting, but were always willing to arrange terms which never could be regarded as onerous, and they expected the same justice to be meted out to them.

Major-General C. E. WEBBER, C.B., also spoke on the working details of the Company's business. After which, a few unimportant questions were asked by the shareholders, and having been answered by the Chairman to their satisfaction, the motion for the adoption of the report and accounts was unanimously adopted.

The retiring Directors, Mr. E. Woods, C.E., Major-General Webber, and Lord Sudeley were afterwards unanimously re-elected, as were also the auditors, Messrs. Cooper Bros. and Co.

The CHAIRMAN then briefly explained the scope and intention of the following resolutions, which were unanimously agreed to.

Resolution 1—"That the provisional agreement entered into between the International Electric Company (Limited), by Ernest Cooper, the liquidator, of the one part, and the corporation of the other part, dated 31st December, 1886, and submitted to the meeting, be, and the same is hereby sanctioned, adopted and confirmed, and that the Directors be authorised to carry the same into effect, with or without modification."

Resolution 2—"That in accordance with the terms of the agreement mentioned in the above resolution, the Directors issue to the liquidator, or to such persons and in such manner as the liquidator of the International Company shall (in writing) direct, fully paid £5 shares in the capital of the corporation, such shares not to exceed in number 1,476."

Resolution 3—"That the Directors be empowered to issue and offer at such times to such persons, whether members of the corporation or not, and at such premium, but not under par, as they may think fit, not exceeding 10,000 shares in the capital of the corporation, on which £3 will be called up."

On the motion of Mr. YOUNG, seconded by Mr. NEIL, a vote of thanks was accorded to the Chairman, who briefly acknowledged the compliment, and the proceedings terminated.

The Swan United Electric Light Company (Limited.)

The fourth ordinary general meeting of this Company was held at the Cannon-street Hotel, on Tuesday, under the presidency of Mr. J. S. Forbes.

The SECRETARY read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Ladies and gentlemen, the report is very short, and not too satisfactory; but perhaps I had better take you at once to the accounts, and begin with the profit and loss account, because that tells really the story of the year. You will have seen there has been some progress in the figures if you have had an opportunity of comparing them with those of the preceding year. I am not quite sure whether we should not in future print in the current report the corresponding figures of the previous twelve months, because that would enable proprietors at a glance to see where we were moving. Comparing the present figures with those of the preceding year, we have, as you will see, made some progress in sales. After all, the sales are the kernel of the nut. They are £22,000, against £18,900, transfer fees, interest, &c., £1,269. 13s. 4d., against £213. 4s. 6d., and the amount of stock on hand to September 30th, which is the period up to which we are now dealing—a little late in the year perhaps—is £8,945, against £7,111. On the other side of the account, the stock on starting the year, on the 1st October, was £10,598, a considerably greater amount of stock than at the corresponding time of the previous year, when it was only £4,187; purchases £4,763, against £12,708; Directors' fees, salaries, and so forth, £2,267, against £4,434; Mr. Swan's salary, wages, and expenses amount in the total to £2,667, against £5,217; wages and expenses at factories £7,932, against £8,621; depreciation £1,500, against £1,754; and then you will see a special reserve, against depreciation of plant, £3,000. You will notice below that entry the balance to profit for the year is £4,768. 11s. 5d., which would, of course, have been to the good but for the special reserve fund of £3,000, which I will explain presently. That leaves a balance of £1,768. 11s. 5d. to the good, which we have carried to the diminution of loss in the balance-sheet. You will see by the balance-sheet that the loss up to the 1st September, 1885, is £7,602, and we have applied the profit to the 1st of September, 1886, to the diminution of that amount. Having just skimmed through the accounts I will follow the order of the report; but I will just say, while on the subject of accounts, that the application of that small available balance to the wiping down of the loss is so much to the good, because it is quite clear we must wipe out the losses of the early years' trading before we can distribute any profits in the succeeding years. Paragraph 3 will explain in few words the reason

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why, instead of applying the whole of the profit of the year to the diminution of the previous loss, we have carried £3,000 of it to a special reserve. It is simply this, that according to the laws of France and Germany, in order to maintain our patents in those countries, it is necessary to carry on the manufacture there, and we have been manufacturing our lamps at Lille, where we had to spend a considerable amount of money, as you will see by the previous accounts, on premises, plant, and so forth. There has been in France such a change of the law in that respect, however, that it enables us materially to reduce our establishment there, and as we find in Germany a much greater possibility of the development of trade, and as labour and other matters are more manageable and economical, we have determined to make, for the present at all events, our chief factory at Kalk, near Cologne, and to restrict the Lille factory to lamps required for France only, and inasmuch as we saw it would involve a possible loss to move our machinery, &c., from Lille, we thought it more prudent to carry against the year's revenue a reserve fund of £3,000 until we knew the worst of this policy. Now about the state of things abroad. Litigation prevails there, as it does in England. I can only hope that it will have the same result. The ladies and gentlemen present are shareholders also in the Edison and Swan Company in England, who, you all know, have been going on litigating for some two or three years—ever since we started, in fact, and it is only within the last two or three weeks that, on appeal, we have succeeded so far in establishing the patents of the two companies—the Swan and the Edison—which makes or will make our lamps so valuable. It has been a very slow process and a costly one. After spending a great deal of time, money, and patience, we have succeeded on appeal in establishing the validity of two of our most important patents—the Edison and Cheesborough. It is the same thing in Germany. I explained at the last meeting that there the Swan and Edison Companies, instead of having their forces together as in this country, and presenting a strong front to the world generally, are litigating. Mr. Swan says Mr. Edison is a great infringer, and Mr. Edison says Mr. Swan is a great infringer; and the consequence is that we are face to face with the Courts, and we are now appealing. The Swan Company did not succeed in the first tussle, and though they had the representatives of the technical department—the patent office of Berlin—in their favour, the Court before whom the case was heard came to the conclusion that there was an infringement. Well, we are doing there what other people have done in England—we are appealing, and we have some reason to believe, or at all events to hope, so far as the technical German legal mind has expressed itself, that we may ultimately succeed. We did not want to press the issue, and we have therefore tried negotiations to bring about an understanding. But German minds are a little difficult to move to a decision, and there have been numbers of propositions as to the terms upon which we should compromise matters, but we have not been able on our side to concur in the views of our friends. They are a little too hard, and, as the German manner is, they want 25s. for a sovereign, and we do not see our way to give it. There is one safeguard in Germany which does not prevail in England, namely, that supposing we are beaten, according to German law you can call upon a patentee to grant a license at a moderate rate to manufacture the patented article. Suppose, then, the worst should come to the worst (which we all hope will not be the case)—but supposing we are beaten, the probability is that we should get a decree of the Court authorising us to manufacture lamps under our own process conditional on our paying some small royalty to the Edison Company. Of course, we think we can manufacture the lamp at all events as cheaply as the Edison Company. Probably the power to manufacture and sell the lamp at a small royalty, coupled with the control of the market in point of price, would put us in a position of some advantage. I hope myself it will end in fusion, and that what we have managed in England wisely may be well done in Germany. While the litigation is pending, there is no doubt the public are prevented from going as fully into the use of this lamp as they otherwise would do. But its use is being rapidly developed in this country. I do not know whether anybody here has been to the Grosvenor Gallery lately, but I had the pleasure of dining there the other evening, having gone in order to see what an admirable institution the Edison-Swan lamp is. If anyone wants to see Vandyck's pictures at night by the electric light he may see them there. Of course they do not appear quite so good as when they are seen in the day time, but the light is a capital one for showing such works of art. The enterprising president of that gallery, Sir Coutts Lindsay, has formed a company for putting up installations of the electric light, and they are now lighting a great area round the Grosvenor Gallery, and are extending their operations in all directions. The engineers and the Directors of the Company told me at that dinner that they started on Saturday night a dynamo for supplying 7,000 additional lights, and in the course of twelve months from this time they will have erected on their premises machinery by which they can feed 100,000 lights. That is very satisfactory to us, because one can hardly believe that such an extension of electric lighting as that contemplated by Sir Coutts Lindsey's company can take place without greatly benefiting this Company, as our lamps are undoubtedly the best in England. The lamp must be made and sold by us, or somebody else will have to pay something to us for it by way of royalty. That is rather comforting to the Swan Company, because, if you look at the balance-sheet, you will find that a very considerable part of our whole interest is invested in shares in the Edison and Swan Compny—more in fact than half our capital. You will observe that the whole of the capital is £337,933, of which £208,478 is invested in the British Edison and Swan, and there is comfort in the fact that holding that enormous share in the British Company, the Court of Appeal upheld, as you will see in paragraph 5, the judgment of Mr. Justice Butt in reference to its patents. It does not do to predict, but it is within the bounds of possibility that the British Company may, under the influence of that decision, and by the possible expansion of business, be in a position some day or other to pay a moderate dividend—perhaps at no very remote period. You will appreciate what that means. Every 1 per cent. they pay will give you £2,000 net income; every 2 per cent. will give you £4,000, and so on; so that when they come to pay a dividend of 5 per cent.—a very small contribution, considering the enormous risk they have run and the benefit they have bestowed on the community—that will give you £10,000 per annum, and that sum will enable you to pay something over 3 per cent. on the whole of your capital, even assuming what is exceedingly improbable, that the foreign business will be worth nothing. But some of us think that the foreign business may be quite as valuable as our home business. Mr. Stearn has a great belief that it will be even better. If that be so, it will be so much the better for you, because two lamps working on the same lines will give you a great advantage. The progress of electric lighting on the Continent has not been so rapid as was expected. You could not expect it to progress much in the face of litigation and competition; but I daresay the competition, which is very keen, will have the effect of bringing about—what we all want to see—a greater development of it. Of course our Company have made up their minds not to run the risk of putting up installations. We are quite satisfied to play the modest *rôle* of lamp making, resting on the sound ground that the lamp is the key of the position, because all lighting suitable for the internal illumination of houses, factories, and kindred places not out of doors, must be provided by the Edison and Swan lamps. People who have to build engines, dynamos, leading wires, and so forth, do so with the certainty that the end of their efforts can be made profitable only through one of these little glass balls. These little balls mean your property, and constitute, as I have said, the key of the position, and you profit by the enterprise and ingenuity of all those people. The electric light is now beginning to spread in all directions, and we therefore expect in a reasonable time to reap the harvest. We have had a long time to wait for it. I do not know that I need say more, but I shall be quite prepared to answer any question or to make any further statement that I may be called upon to do by the proprietors. Meantime I move, "That the report and accounts now submitted be adopted."

Mr. F. R. Leyland seconded the motion, observing that after the remarks of the chairman it was not necessary for him to say much. But he would like to supplement them on one point to which the chairman had adverted—namely, their reasons for congratulation on the success of the litigation in the case of the Edison lamp in this country. It would appear at first sight rather inconsistent that, having succeeded in establishing the validity of the Edison patent in this country, they should hope to succeed in establishing its invalidity in Germany. The explanation was a very simple one. The Edison patent in Germany was not framed on the same lines as it was in this country. The claims of that patent, which they succeeded in establishing the validity of in the British Courts of Justice, did not apply to the patent in Germany, and they had extremely good grounds for thinking that they would succeed in establishing the fact that Edison's patent in Germany would not prevent their manufacturing the lamps there. In this country, however, they possessed a patent that would prevent other people from making the lamp.

The Chairman, in reply to a shareholder who asked whether the Company's liabilities were the same as in 1884, said that they were not. If the gentleman would look at the balance-sheet he would see how that came about. In last year's accounts there were £17,883 outstanding calls which had been reduced to £781. They had now got rid of the Holborn and Benwell factory, which was fully explained in the report of the Swan and Edison Company. The Swan Company had then divested itself, so to speak, of its individuality, and went into partnership with the other Company; but outside the bargain was the foreign business, which was an asset of the Swan Company, in addition to their share in the British Edison and Swan.

Mr. Sowerby asked why they wished to leave Lille, and what effect that would have on capital and revenue.

The Chairman said that the object of reducing at Lille was to reduce the current expenditure. They could not reduce current expenditure without adopting that policy, and to go through that operation they must necessarily sink a certain amount of money in depreciating the value of the plant, and on account of the penalties they were under, to get rid of leasehold obligations there, &c. At present they did not know what the loss would be, but they must make a little sacrifice. The question was whether they should go on spending two or three thousand—at all events a considerable sum—annually, over and above what they need spend, or sacrifice a small amount of capital, say two or three thousand pounds. They thought it prudent not to carry a loss of that sort to capital, because the very object of it was to unburden revenue. If they did not incur a loss of capital, whatever it might be, then for several years they must spend out of revenue perhaps £800, £900, or £1,000 a year, and it really was, when they came to consider it, a charge which revenue ought to bear. It was a sacrifice of capital in order that they might spare income from year to year. They would very soon overtake the loss involved in the depreciation, and in moving their business by the annual saving in expenditure. But of course they would have liked very much indeed, if they had thought it prudent, to carry the £3,000 to profit and loss. It would have looked so much better, but he did not think it would have been as sound or so much in the interests of the proprietors as the course they adopted. It might be, when they came to wind up the matter, that the £3,000 would not be required, in which case the amount would be written back into profit and loss.

Mr. Scott: Are you closing the factory at Lille altogether?

The Chairman: No, we are only diminishing it. We are obliged to keep up the manufacture, but we shall do so only to a limited extent.

A Shareholder said that as the question of the liability of the Company had been mentioned, he would like to ask whether on the part of the

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Edison and Swan Company there was any likelihood of a call being made. The question of the liability on the shares in that concern was one that caused the shareholders some anxiety.

The CHAIRMAN replied that the Directors of the Swan Company happened to be the Directors of the Edison and Swan Company also, and he thought that the proprietors of the latter would be quite as reluctant to the idea of a call as the proprietors of the former. There was no present idea of making such a call, and if one were necessary—which he thought would not be the case—as far as the shareholders in the Swan Company were concerned, he might relieve their minds by saying that they had money to meet it. They had sundry debtors £5,588, stock on hand £8,945, investment in Prussian consols £13,116, loan on mortgage £14,300, investment in consols 3 per cent. £1,987, and cash on deposit and in hand £9,383. They had all that amount if it were necessary to apply it to such a purpose; but the Swan Company being the proprietors of £208,000 of the capital of the Edison and Swan Company, the proprietors in the former were not very likely to consent to a call being made, unless they were thoroughly satisfied that it was judicious to sanction it. If a call were necessary they would have to be satisfied of its necessity, and if it were necessary the Directors would consult them about it first. The Board would never dream of responding to a call without consulting the shareholders. There was an uncalled liability on the shares of 30s.; but the Board could easily pay, say, a 10s. call without appealing to the proprietors. In further reply to a shareholder the Chairman said that the Company began by making some mistakes—not an uncommon thing in the lives of young people—and their earlier experience taught them that installations did not pay, and that if they were to supply installations they would require a great deal more capital than was represented by the shares. The Directors therefore elected, with the full concurrence of the proprietors, to abandon the idea; but they had to pay very heavy penalties before they could alter their policy. They were going to rest on their oars now, being quite satisfied with lamp making, and feeling sure that no installation could exist without their lamp. So far as could be foreseen there was not any chance of a call being wanted on the part of either of the two companies unless the development of their line of business involved a reversal of their present policy. For instance, if they were to see that by some advance of science or change of machinery there was a great profit to be made by the storing business, they were quite free to take it up. At the same time they would prefer other people to do so.

A SHAREHOLDER: Is the law suit over, or are Messrs. Woodhouse and Rawson to appeal again?

The CHAIRMAN: They have the power to appeal to the Lords, but we do not know whether they will or not.

The SHAREHOLDER: We got our costs?

The CHAIRMAN: We shall get them.

Mr. STEVENSON, M.P., said he did not think the proprietors should separate without congratulating the Directors on the successful way in which they had passed through their legal troubles, and placed the Company on such a satisfactory footing. He thought that they would all approve of the policy sketched out by the Chairman, that it was rather to their interest not to make installations, but confine their attention to the manufacture of lamps, and to the getting of money for royalties. His own personal feeling would be rather to look out for royalties in the future than to extend their manufacture. If they could by a system of royalties get others to go into the manufacture of lamps, that would be a source of revenue with which he would be quite content, for he thought it would place the Company in an easier and more profitable position than to perform the more difficult task of supplying the lamps themselves, more especially in view of the changes that the lamps might undergo from time to time, and the possibility of further litigation.

The CHAIRMAN said he was very much obliged for the suggestion of his late colleague. It was, of course, a very material issue that they had to try, having due regard to the interests of the proprietors, as to what course they should take under this litigation. They were old enough to know the unwisdom of dealing with a victory too severely. One had to stand up for one's rights in the world, but next to winning there was no better quality than that of using a victory discreetly, and they were very much exercised at this moment to know what exactly to do. They were not relying on their own judgment entirely in the matter, because they had had the best legal advice probably in the Kingdom, combined with a rare knowledge of the world—and not mere unassisted technical legal knowledge—to help them, and he thought it was not at all unlikely that they would take Mr. Stevenson's course to treat with all mankind on the basis of royalties.

The motion was then adopted.

Mr. STEVENSON, M.P., next proposed the re-election of Mr. J. S. Forbes as a Director of the Company.

Mr. W. C. QUILTER, M.P., in seconding the motion, said that he was one of the Board interested in the Swan Company proper, although his colleagues were interested in the Edison and Swan Company. It would be in the recollection of some of the proprietors present that a little doubt was experienced at first whether their Chairman, in his multifarious engagements, could find the time to devote to this Company which was necessary in the then condition of their affairs. He (the speaker) was very happy to inform them that since he had been on the Board the Chairman had given unwearied and most diligent attention to their interests. It must have been patent to all who had heard the discussion that Mr. Forbes possessed a great knowledge of their affairs, added to the immense experience and ability which he could always bring to bear on any concern with which he was connected. He had much pleasure in seconding his re-election.

Mr. LEYLAND having also borne testimony to the Chairman's devotion and attention to the Company's affairs, the motion was carried unanimously.

The CHAIRMAN, in acknowledging his re-election, said that being in a bad thing he never liked to leave it so long as it was in trouble. When it got all right he was not so particular. It was a very odd thing that he was often reminded of the many things he had to do, and that he could not really do any of them. That was not so. His value—if he had any—consisted in a certain natural aptitude for making the best of bad things. It was the way that the world was carried on. It was only the hopeful—not the dispairing—people that could do the world any good. It had been his misfortune to be mixed up with things that had not been very wisely started—in fact, he generally found them in a mess—and when one had "gone through the mill" once or twice, one acquired an aptitude for dealing with such bad things. And more than that, they were generally so very much alike that they did not take up so much of his time as people might be apt to imagine. He thanked them for their renewed confidence, and hoped that the next time they met he would have a more progressive state of things to report and a more palatable story to tell. He concluded by moving the re-election as a director of Mr. E. Batt, which was seconded by Mr. LEYLAND, and agreed to.

The auditors, Messrs. Quilter, Ball and Co., were subsequently reappointed, and the proceedings terminated.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 18th inst. amounted to £3,481.

THE MAXIM-WESTON ELECTRIC LIGHT COMPANY.—A dividend of 5 per cent. for the last twelve months has been declared by the Maxim-Weston Electric Light Company.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED). Notice is given that the transfer books of this company will be closed from the 21st inst. to the 1st prox., both days inclusive, preparatory to the payment of dividends to all shareholders on the register on the 21st inst.

THE WEST AFRICAN TELEGRAPH COMPANY. — The half-yearly interest on the debenture bonds of the West African Telegraph Company will be paid at the company's bankers, the National Bank of Scotland.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 18th February were £2,822, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th inst. are £2,923, as compared with £2,600 in the corresponding period of 1886.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	Closing Prices. Feb. 23.		Business Done Week Ending Feb. 23. Highest.	Lowest.
Anglo-American	31,	32	31½	31
Do. Preferred	51½,	52½	53	52
Do. Deferred	11,	12	11¾	11½
Brazilian Submarine	10⅝,	10⅞	10⅞	10⅝
Cuba	11,	11½	11¾	—
Do. Preference	18,	19	18½	—
Direct Spanish	2,	2½	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	7¾,	8	8	7⅞
Eastern Telegraph	10½,	10¾	10⅝	10½
Do. 6 per Cent. Preference	13,	14	13⅜	13 9-16
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	10⅞,	11⅛	11¼	10½
German Union	8¾,	9¼	—	—
Globe Telegraph and Trust	4⅝,	4¾	4¾	4 11-16
Do. Preference	11⅝,	11⅞	11⅞	11⅝
Great Northern	13½,	13¾	13½	13¼
Indo-European	34,	35	—	—
Reuter's	6¾,	7¼	—	—
Submarine	190,	200	—	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	8½,	9	8 13-16	8⅝
Western Brazilian	7⅝,	7⅞	7¾	7 11-16
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	102,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¾,	⅞	13-16	—
Oriental	3-16,	5-16	—	—
United Telephone	12½,	12¾	12⅝	12½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2,	2½	2½	2
Do. (fully paid)	3½,	4	—	—
Swan	1⅛,	1⅜	1¼	1 1-16
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	37,	38	38½	37½
India Rubber, Gutta Percha, and Telegraph Works	21½,	22½	22⅜	22

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NOTES.

THE LIGHTING OF THE PARIS HOTEL DE VILLE.—The Municipal Council of Paris has decided to have about 2,000 incandescent lamps fitted up in the Hotel de Ville.

"SCIENTIFIC NEWS."—A new monthly journal has made its appearance, entitled *Scientific News for General Readers.* The first number contains some interesting matter, and is nicely illustrated.

QUADRUPLEX WORKING IN INDIA.—Quadruplex working has been successfully established upon the line between Bombay and Madras, by Mr. J. J. Allen, of the Indian Telegraph Department.

THE STATTER-JOEL DYNAMO.—We are requested to state that the new dynamo which we described and illustrated last week is constructed by Messrs. Statter and Co., under the patents of Mr. Joel.

DIEHL'S INDUCTION SYSTEM.—Referring to this system, which we described at some length last week, we see that the French journals state that a precisely similar arrangement was patented by M. Jablochkoff as long ago as 1876.

THE ELECTRIC LIGHT FOR HARBOUR DEFENCE.—It is stated that electric search lights have now been provided for all the more important commercial ports, including Hull, Newcastle, Edinburgh, Glasgow, Liverpool, and Bristol.

PERSONAL.—The King of Portugal has been pleased to confer the distinction of Knight Commander of the Order of Christ on Mr. E. W. Parsoné, the engineer and manager of the southern division of the West African Telegraph Company.

THE FALLS OF CLYDE.—The question of utilising the power of these falls by means of electric transmission is once more being discussed in the district, and at a meeting held at Lanark a few days ago a committee was appointed to consider the question.

ELECTRIC LIGHTING IN THE NAVY.—The contract for fitting H.M.S. "Hero" at Chatham Dockyard with 253 incandescent and 4 search lights has been placed with Messrs. Goolden and Trotter, of Westminster. The work was commenced on Monday last.

ELECTRIC TRAMWAYS IN ALGERIA.—An electric tramway is to be constructed in the town of Bône, Algeria. This line will be about three miles in length. Two similar lines are projected in different parts of the country; each of these would be about five miles in length.

BELGIUM.—The incandescent lamp is making steady progress in Belgium. Among recent installations of interest is the lighting of the village of Berchem, near Antwerp, and that of a new hospital at Watermael, which has been supplied with 350 lamps fed by gas engines.

THE INDIAN TELEGRAPH DEPARTMENT.—A telegram from India states that the director-in-chiefship of the Indo-European Telegraph Department, rendered vacant by the death of Sir J. Bateman-Champain, will be united with that of the Director-General of Indian Telegraphs.

SIR DAVID SALOMON'S PAMPHLET ON ACCUMULATORS.—In reply to several inquirers we are now enabled to state that a second and revised edition of Sir David Salomon's pamphlet on "The Management of Accumulators" will shortly be issued by Messrs. Whittaker and Co.

"LAXTON'S BUILDERS' PRICE BOOK."—We have received from Messrs. Kelly and Co. a copy of the seventieth edition of this useful work. The electrical portion is good so far as it goes, but might be usefully extended so as to include a wider range both in the articles quoted for and in the manufacturers' names.

THE SPANISH NAVY.—The Spanish Government find that they are now able to supply their wants in the way of electric light equipment for their war ships without going beyond their own frontiers. The lighting of the new cruisers "Numancia" and "Pilar" has been entrusted to the Sociedad Espanola de Electricidad.

THE LANCASHIRE AND CHESHIRE TELEPHONE COMPANY.—This company sends us the latest issue of their "Telephone Directory," which has by this time grown to a bulky volume, and contains a great deal of information of interest to the residents in these counties. We are glad to see that the telephone is making such good progress in that quarter.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS. A meeting of the Society of Telegraph-Engineers and Electricians will be held at the Institute of Civil Engineers, Great George-street, S.W., on Thursday, March 10, 1887, at 8 p.m., when a paper "On Reversible Lead Batteries and their Use for Electric Lighting" will be read by Mr. Desmond G. FitzGerald, member.

THE SOCIETY OF ARTS.—At a meeting of the Society of Arts, held on Wednesday, 25th February, Mr. J. W. Urquhart read a paper on "Recent Advances in Sewing Machinery." A number of sewing machines, lent by several of the leading makers, were exhibited in motion, being driven from a countershaft from a small electric motor, which was supplied with current from the society's dynamo in the basement. The motor was lent for the occasion by Messrs. Immisch and Co.

ALARMING.—Some of the electric tramcars in the States, which are run from overhead conductors, contain a notice to the effect that "the engineer is to oil the travellers every three hours." Electricians, of course, will understand that the "passengers" are not referred to; but it is not surprising to hear that the notice gives rise to a good deal of uneasiness in the minds of many people. Probably the company will find it as well to adopt the term "trailer" instead of "traveller."

THE "SPECIALIST" SERIES.—Messrs. Whittaker and Co. will publish shortly a second and much enlarged edition of "Magnetic and Dynamo Electric Machines," being the first volume of their "Specialist Series." For the new edition some alterations in the text have been made, and a preface and a chapter on the latest types of generators have been written by Mr. W. B. Esson. The work contains some thirty-seven more illustrations, and gives full particulars of the most modern machines.

THE AMERICAN TELEPHONE LITIGATION.—The arguments before the United States Supreme Courts in the combined actions for infringement of the Bell Telephone Patents, have now been concluded; but it is anticipated that several months will elapse before judgment is delivered. The Bell Company is very confident of success, but it is said that the Drawbaugh claims were put before the Court in a remarkably able manner, and created a powerful impression. This, however, may probably be taken as an *ex parte* statement.

ONE FOR THE PROFESSOR.—A certain learned professor, whose name is not altogether unfamiliar to our readers, in the course of a long climb to the summit of a Highland mountain, took the trouble to enlighten the gillie by whom he was accompanied regarding the electric light, the telephone, and other modern inventions. As Donald never condescended to give the slighest indication of either interest or wonder, the professor expressed his surprise at his silence, on which the

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Highlander confidentially informed him that he was "a big leer himsel'!"

THE PARIS-BRUSSELS TELEPHONE LINE.—This line was opened for public use on the 24th ult., the charge being 2s. 6d. for five minutes' talk. At present during the daytime only the Bourses of the two cities are in actual communication; but after business hours the wires are switched on to the General Post Offices in each town. At Paris, where metallic circuits are alone in use, there would be no difficulty in working over the ordinary exchange wires; but this cannot at present be done at Brussels, where earth returns are employed. The authorities are now seeking for some efficient means of translation to get over this difficulty.

WEST AFRICAN CABLES.—The Loanda São Thomé section of the West African Telegraph Company's system suddenly broke down off the Congo River. The cable will be shortly repaired, as the Silvertown Company's cable steamer "Buccaneer" sailed from London on the 21st ult., arrived at Teneriffe on the 28th, and is expected to reach São Thomé on the 16th inst. Before undertaking repairs the ground will be very thoroughly surveyed by Mr. E. W. Parsoné, who is in charge of the work, and a new route will probably be chosen for the cable to be laid over. Mr. G. March Webb, chief electrician, and Mr. A. S. Thomson, senior commander in the Silvertown Company's service, accompanied the "Buccaneer."

BERLIN STREET LIGHTING.—The *Staedtische Elektrizitaets-werke* Company, of Berlin, has completed an installation of 36 arc lamps in the Leipziger Strasse, at Berlin. According to the terms of the contract entered into between the municipality and the company, the lamps are to furnish a minimum of 2,000 hours of lighting per annum, at the rate of 3d. per hour per lamp, so that the annual cost will be not less than £900 per annum. This company is also making preparations for supplying incandescent lighting to a large district in the same quarter of Berlin. The cables will shortly be laid in the Spittlemarket, the Behrenstrasse, and the Zimmerstrasse, and it is anticipated that fully 12,000 lamps will be taken up during the course of the ensuing twelve months.

MAGNETIC HEATING.—We have received a private letter from M. Bláthy with further reference to the above subject, from which we make the following extract:—"You would much oblige me by inserting a note for the purpose of correcting an error which slipped my pen in the letter you have published—*i.e.*, the maximum energy dissipated in one kg. of iron by one reversal of direction of magnetisation has double the value indicated there—that is 0·14 volt-coulomb, or 1,400,000 ergs. Only the very softest qualities of iron were submitted to the experiments, as with iron not suitable for the purposes we had in view, the magnetic friction would have consumed much more energy." M. Bláthy has also kindly promised to write for us a full account of these experiments, by which he has separately measured the loss of energy due to Foucault currents and to magnetic friction.

ELECTRIC LIGHT INSTALLATION AT A FLOUR MILL.—Some extensive flour mills belonging to Mr. J. M. Bird, of Lynn, Norfolk, have just been lighted with sixty incandescent lamps by Mr. Wilson Hartnell, of Leeds. The installation consists of a 4 horse-power Gippeswyk vertical engine, fitted with a Hartnell patent governor, driving direct by belt from the fly-wheel, at a speed of 190 revolutions per minute, on to a No. 2 Crompton compound-wound dynamo, capable of driving 90 glow lamps at a speed of 1,100 revolutions per minute. The lighting is divided into two distinct circuits, viz., mill and warehouse. These circuits are controlled in the dynamo room by Hartnell's double pole-switches, two in number. The number of lights in the mill circuit is forty, in the warehouse circuit twenty. The glow lamps are of Edison and Swan type, and are all suspended by incombustible flexible leads from the ceilings.

LONG-DISTANCE TELEPHONY.—On 7th February last experiments in long-distance speaking were made at the offices of the Northern District Telephone Company, Sunderland. The first experiment consisted in joining various trunk wires together, making a circuit 90 miles long, or 180 miles of wire. Speech was carried on over this length of wire with perfect distinctness, and the difference between speaking over this distance and speaking locally was scarcely perceptible. The trunk wires between Middlesbrough and Newcastle were then connected together and put through to Sunderland and Darlington, making a distance of about 220 miles, or 440 miles of wire. Though the result was not so good as in the former case, conversation was easily and distinctly carried on. The wires at Newcastle were working through an ordinary switch-board, otherwise there would have been still less difference between the long and shorter circuits.

THE SUEZ CANAL.—On the 1st of March the arrangements for navigating the Suez Canal by night came into operation throughout the entire length of the water-way. The experience which has been gained in the navigation by electric light of the southern portion of the Canal, which has already been in operation for a period of more than twelve months, has been of a highly favourable character. The pilots declare that it is easier to direct the course of a vessel after dark than during the day, owing to the entire absence of that optical disturbance of the atmosphere, arising from the heated sand, which is so frequent on the banks of the Canal during the hours when the sun is above the horizon. The regulations now in force require that every vessel proceeding by night shall be provided with an electric light sufficiently powerful to enable the pilot to see both banks of the Canal distinctly to a distance of 1,200 metres ahead. In addition to this, the Canal is illuminated with eighteen stationary lighthouses, and seventy-six luminous buoys. The latter are placed in the curves, and, if upon the African side, show a red light, and upon the Asiatic side a green light. When two vessels meet at night, the one which has to put into a siding must extinguish its electric light until the advancing ship has passed by. The first vessel to pass through the whole length of the Canal under electric light was the P. and O. boat "Siam." The passage was made in fifteen hours, which represents a saving of at least a day and a half.

SMALL ELECTRIC MOTORS.—At a meeting of the American Institute of Electrical Engineers a paper on "Small Electric Motors" was read by Mr. S. S. Wheeler. The author is of opinion that small motors should be constructed on the lines of larger dynamo machines, except that the armatures might with advantage be made somewhat larger in proportion. A motor known as the "C. and C." motor, which had been designed more especially for light work, such as driving sewing machines, &c., and had already met with considerable success in practice, was designed on these lines. The armature is of the Gramme ring type, and in order to make the construction as economical as possible the ring is constructed in two halves, which were wound separately in a lathe, and afterwards bolted together. A motor with an armature ring 3in. in diameter, running at 1,500 revolutions, with a current of 20 amperes, under an E.M.F. of 7 volts, gave about one-tenth of a horse-power, which was amply sufficient to drive a sewing machine. The

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efficiency obtained is rather over 50 per cent. About 600 of these machines are actually in use in the States. The great desideratum was undoubtedly to discover a primary battery capable of giving a current of 20 amperes for six or eight hours at a stretch, and with the minimum of trouble. Although the C. and C. Company had got hold of a battery which gave better results than any other which they knew of yet, he was free to confess that they would much like to find something even better. No details of this battery were furnished in the paper.

GAS AND ITS PARTISANS.—The *Cornish Telegraph* returns to the attack, and comments upon our article of February 10th under this heading. Unfortunately for the *Cornish Telegraph*, in jumping from the pan it has jumped into the fire. Surely if our contemporary had been "perfectly unbiassed upon the question" information would not have been solicited from those interested in "gas," or from those who failed to establish the electric light. Has a speculative gas company never been a failure? Would the supporters of the gas industry accept the statistics drawn from such a source as of value to prove the utility or inutility of gas? Would they not rather laugh them to scorn, and suggest the use of a little more common sense in providing favourable or unfavourable arguments? Results from a company started upon an unsound basis cannot be taken as trustworthy, nor can the work of speculators and speculating companies floated on the top of a boom be regarded as worthy of a place in calm discussion upon the merits of electricity as an illuminant. If our contemporary desired trustworthy information, why did it not apply to successful companies or to publications that must know more of the industry than gas journals? The reply is obvious; information of an unsatisfactory character was desired, and the best efforts possible made to get it. Perhaps our contemporary will accept our suggestion, and read the letters of the late Mr. Coope to *The Times*, or Col. Festing's report on "The Cost of Electric *versus* Gas Lighting." We cannot oblige our contemporary by reprinting reports common to all who use them and well known to our readers simply because the *Cornish Telegraph* is ignorant of their existence.

TALL CHIMNEYS AND LIGHTNING CONDUCTORS.—At the last meeting of the *Société des Ingénieurs Civils* M. Debar gave a very graphic description of a case in which a tall chimney unprovided with a lightning conductor had been suddenly destroyed by a sort of spontaneous outburst of atmospheric electricity. The occurrence certainly seems to have been one of a very remarkable character. At Fécamp, a village on the French coast, the weather being perfectly calm, no wind and a smooth sea, about 10:30 p.m. on the night of the 9th January, M. Debar was standing at a short distance from the chimney of a factory, which rose to a height of 30 metres, when suddenly a vivid blaze of light flashed forth, a tremendous explosion was heard, and the chimney was seen literally to burst asunder at a point about six metres from the base, the fragments being thrown in all directions, inflicting great damage upon buildings within a radius of 100 metres. The place looked as if it had suffered from a severe bombardment; happily no personal injury was sustained. Large quantities of the bricks seem to have been completely pulverised, and the ground was covered with brick dust for a distance in one direction of more than 400 metres. We are much suprised to find that M. Debar, after stating that there were many tall chimneys in this district unprovided with lightning conductors, expressed the opinion that the effect would have been equally disastrous in any case as no conductor could possibly have proved a channel for the safe passage of such a terrific discharge. This might easily be true, but surely M. Debar is aware that the function of a lightning conductor is chiefly to avert the attainment of such tremendous difference of potential as is here indicated. In the present state of our knowledge, the moral of the catastrophe is certainly not that a lightning conductor would have been unavailing, but rather that the owners of the factory have been guilty of the most culpable negligence.

A SIMPLE AND CONVENIENT FORM OF WATER BATTERY.— Prof. Rowland, in *Silliman's Journal* for February, writes:— "For some time I have had in use in my laboratory a most simple, convenient, and cheap form of water battery, whose design has been in one of my note-books for at least fifteen years. It has proved so useful that I give below a description for the use of other physicists. Strips of zinc and copper, each two inches wide, are soldered together along their edges so as to make a combined strip of a little less than four inches wide, allowing for the overlapping. It is then cut by shears into pieces about one-fourth of an inch wide, each composed of half zinc and half copper. A plate of glass, very thick and a foot or less square, is heated and coated with shellac about an eighth of an inch thick. The strips of copper and zinc are bent into the shape of the letter U, with the branches about one-fourth of an inch apart, and are heated and stuck to the shellac in rows, the soldered portion being fixed in the shellac, and the two branches standing up in the air, so that the zinc of one piece comes within one sixteenth of an inch of the copper of the next one. A row of ten inches long will thus contain about thirty elements. The rows can be about one eighth of an inch apart, and therefore in a space ten inches square nearly 800 elements can be placed. The plate is then warmed carefully so as not to crack, and a mixture of beeswax and resin, which melts more easily than shellac, is then poured on the plate to a depth of half an inch to hold the elements in place. A frame of wood is made around the back of the plate with a ring screwed to the centre, so that the whole can be hung up with the zinc and copper elements below. When required for use, lower so as to dip the tips of the elements into a pan of water and hang up again. The space between the elements being $\frac{1}{16}$in., will hold a drop of water which will not evaporate for possibly an hour. Thus the battery is in operation in a minute, and is perfectly insulated by the glass and cement. This is the form I have used; but the strips might better be soldered face to face along one edge, cut up and then opened."

THE NATIONAL ELECTRIC LIGHT ASSOCIATION OF THE UNITED STATES.—A "convention" of this important association commenced at Philadelphia, on the 16th ult., under the presidency of Mr. J. F. Morrison. The first business on the programme was to receive the report of the "Legal Committee," which has been appointed to consider all questions relating to the law of the United States, so far as the interests of electric light companies are affected. The report of the Committee on Standard Gauge was then read by Dr. A. V. Garratt. It presented an exhaustive account of the labours of the committee, who had weighed all the evidence for and against the gauges in present use, and finally offered the metric as the best gauge. The numbers were taken from No. 1 to No. 100, each number representing a wire of corresponding number of lengths of millimetres in diameter. Thus, No. 1 is intended to represent a wire $\frac{1}{10}$ millimetre in diameter; No. 50 of a wire 5 millimetres, and No. 100 a wire of 10 millimetres in diameter and equal to about a No. 0000 B. and S. gauge. The report was

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eventually adopted and the committee continued, some new members being added thereto, for the purpose of fully carrying out the work and calculating the resistance, weight, &c., of wires of the gauge proposed. We have not learnt what the Edison Companies had to say to this, who, as our readers are aware, have just started a gauge on their own account. We are inclined to think it probable that they are not particularly anxious to induce other makers to follow their lead. A paper was then read by Mr. C. Haskins, on "High Insulation," and one by Mr. Weeks, on "Popular Prejudice Against Electric Light Wires." These papers have not as yet reached our hands; we shall, if necessary, reproduce them either in full or in abstract in a future issue. The following is a list of the papers which remain upon the programme:—"Electric Motors," by F. J. Sprague; "Transmission of Power by Means of Belting," by H. J. Shay; "Plans for Electric Light and Power Stations," by S. A. Duncan; "Underground Wires," by G. L. Wiley; "Incandescent Lighting from High Potential Circuits," by J. Wetzler; "Distribution of Electric Energy by means of Secondary Generators," by Dr. O. A. Moses; "Electrical Education," by Dr. Duncan. It will be seen that this meeting is likely to prove of an interesting character.

Practice versus Theory in the United States.—It is quite evident that nowhere is the proverb which says that an ounce of practice is worth a ton of theory more emphatically believed in than in the United States. And considering the highly remarkable achievements which have frequently been attained apparently from the direct application of that principle, it is not altogether surprising that this should be the case. A striking illustration of the superiority of American electricians to merely theoretical considerations was afforded by certain of the speeches in a debate on the construction of motors which recently took place at the American Institution of Civil Engineers. Some reference to the paper under discussion will be found in another note. Our space will not permit us to reproduce this remarkable discussion, but as a sample we may quote the following observations by an individual whose name is connected with a motor which has achieved a great success in the States. Speaking, in reply to another member who had got a little fogged over his "efficiences," this gentleman remarked:—"What is called commercial efficiency is the same thing as what you mean, taking into account the external and internal resistance in the machine. Take an ordinary dynamo machine; it does not affect the converting power, whether it has a high internal resistance or a low internal resistance. In regard to the amount of current that it is necessary to supply it with in order to obtain a given power, that element is of no importance at all; nobody cares what the internal resistance is. The only trouble about having high internal resistance is that it absorbs the power, and then it prevents self-regulation. There is a great deal of talk about commercial efficiency. The most important thing is just the converting power. If you put 100 volts and $\frac{8}{10}$ ampere on that wire, then put on the friction brake and take out the foot-pounds, the proportion of friction that goes out to the amperes that go in gives the important thing as regards efficiency. The other important thing is how many dollars worth of amperes it takes to give an eighth of a horse-power or a tenth of a horse-power or two horse-power, whatever you want." The speaker's practice, it may be surmised, is a great deal truer than his theory, which in this instance is all false.

The Conduction of Electricity by Gases at High Temperatures. — M. R. Blondlot has presented to the *Academie* a memoir entitled "Researches upon the Transmission of Electricity of Low Tension by Hot Air," of which the following is an abstract:—In the year 1853, M. E. Becquerel discovered that a gas at a high temperature became a conductor of electricity, and stated that the phenomenon could be observed even with a single cell. Some doubt has been thrown in later years upon the accuracy of the statement, but it has been fully confirmed by the experiments which are about to be described. The apparatus employed consisted of a sort of double bell jar placed with its mouth downwards; between the outer and the inner lining a stream of coal gas was caused to ascend, and being mixed with air in its passage a powerful flame could be produced around the inner lining which soon raised it to a state of incandescence. Within this heated jar, but entirely free from contact with any part, were placed two platinum discs, about 3 cm. in diameter. These served as electrodes. By means of this arrangement the air could be raised to a very high temperature, while currents of convection were as far as possible avoided. In accordance with M. Becquerel's announcement it was found that in this case no current would pass until a red heat had been attained. On the other hand, when a column of air is allowed to rise by convection from a heated body a current may be obtained with a single element when a thermometer indicates a temperature of only 70° C. The explanation suggested is that the convection current contains many particles which are themselves far hotter than the mean temperature of the air, as shown by the thermometer, and it is these hotter particles which are alone concerned in conducting the current. In the present apparatus, as soon as a red heat had been attained, an E.M.F. not exceeding one-thousandth of a volt produced a measurable current. It was, however, discovered that this current does not obey the law of Ohm, as on increasing the E.M.F. the current increases more rapidly than the difference of potential. This result, which has been well established, appears to be one of considerable importance as throwing light on the differences between the conduction of electricity in solids, liquids, and gases. It follows that gases, properly speaking, have no specific resistance, as the quantity so measured will depend upon the E.M.F. employed in the experiment. It is probable that the explanation of the phenomenon is to be found in the conduction by convection currents already alluded to. When the air is at the normal temperature it is known that all bodies are coated with a kind of atmospheric film, which therefore serves as an effective insulator. But when the temperature is sufficiently raised this film is driven off, and the gaseous molecules then come into sufficiently close contact with the surface of the metal to carry off a charge of electricity.

Electricity and Gas.—In a paper recently read before the Society of Gas Lighting, U.S.A., by Mr. Jos. R. Thomas, editor of the *American Gaslight Journal*, attention is directed to the question of whether it would be best in the interests of gas companies to install an electric lighting plant as an adjunct to the usual gas-making apparatus, so as to be in a position to furnish both descriptions of light. The author considers that this question should be decided upon local considerations mainly; and that the claims of the so-called commercial electricians do not afford satisfactory evidence as to the profits to be earned by the supply of the electric light, on which point no really reliable information is forthcoming. Some gas engineers were, he said, enthusiastic as to the benefits to be derived from the working of a combined plant; and considered its adoption indispensable to the future success of the artificial lighting business. Others refused to believe that the combined system was necessary for the

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preservation of their supremacy in the matter of light supply; but admitted that there were some reasons in favour of it. A third class ignored the electric light as unworthy of consideration in any shape. Mr. Thomas frankly confessed that he had recently been converted from this view to the ranks of the middle division. He thought the fact that the electric light business had made great strides in the United States during the last two years must be accepted as an issue of the day and time. This had not been secured at a corresponding loss to the gas maker's craft; but, on the contrary, had benefited it by creating a desire for a greater volume of light. One of the greatest inducements to cause the operation of a combined plant was the fact that a number of consumers were found to be anxious for the electric light under any circumstances and at any price; and existing gas companies were in a position to supply it on better terms than a company specially established for the purpose. There were few gas companies who had not sufficient space at their works for an electric lighting plant; and many had buildings well adapted for the purpose. There was also plenty of surplus fuel, sometimes a glut of it, at the gasworks; while the clerical work and establishment charges would necessitate but a slight additional expense. Gas undertakings would thus have a considerable advantage in the matter of establishment charges, ground rent, and cost of fuel, as compared with an independent electric company. He had not a doubt but that gas—light for light—could be furnished much more cheaply than electricity; and pointed out that one good effect of the introduction of the electric light had been the impulse given to inventors in the way of developing the greatest possible "duty" from gas. He thought that in many cases gasmen had been indifferent to the advantage of modern large burners. The electric light had, in consequence, obtained a hold; and whether or not they went in for combined plant, he urged them not to foster the latter at the expense of the former. For if electricity was the light of the rich, gas was most certainly, now more than ever, the light of the poor.

THE SPRAGUE ELECTRIC MOTOR COMPANY.—The *Electrical World* of New York contains the following interesting account of one of the leading electric-motor companies in the United States:—"The Sprague Electric Railway and Motor Company was organised in the fall of 1884, and for two years was strictly a private corporation, no Treasury stock having been issued, and its control and practical ownership having been in the hands of two men, Mr. E. H. Johnson and Mr. Sprague. Considering the circumstances its success was remarkable, and by the end of 1886 it had nearly 250 machines, varying from one-half to 15 horse-power, in operation in different parts of the country on a great variety of work. On the 31st of December, 1886, the capital was increased, and a portion of its Treasury stock issued. So strong was the belief in the success of this company, and so thoroughly good a record had it made, that nearly double the amount of stock which was authorised to be issued was at once subscribed for by the few people who knew of this change in its organisation. The demand for work has grown with such rapidity that it has been found necessary to make extra provision for manufacture. This work is to be divided into two classes, special and standard. Contracts are about to be entered into with the Edison Machine Works at Schenectady, one of the largest factories of the kind in the United States, for the building of standard types of machines for 100 and 200 volts electromotive force, to be run on constant potential circuits. The company are also going to build constant potential machines of 400 volts, and later of 600 to 1,000 volts for special cases of transmission. They expect to carry a stock of not less than 150 machines in Schenectady as soon as arrangements can be completed for handling them. Some very interesting applications of electric motors are now being worked out. The work in Boston has been pushed ahead very rapidly. They are used almost for every class of work, up to a distance of nearly 5,000ft. from the source of supply. About 36 machines are at present in use, but a great many more are being put in at this station, and the present contracts already show a large net revenue from the furnishing of power. There are in operation ten elevators, and there will soon be ten more. Work is also extending in other cities, and motors are being introduced into Lawrence, Pawtucket, Fall River, Springfield, New York, York, Chester, Williamsport, Pittsburgh, Harrisburg, Lancaster, Detroit, Chicago, St. Louis, New Orleans, Topeka, St. Paul, Des Moines, and many other prominent points. It is rather a remarkable fact that in Springfield motors are being introduced to replace the transmission of power by shafting and by wire rope at present used by the Springfield Steam Power Company. In New York a large central station is going to be started, with motors working on either 200 or 400 volts potential, according to the distance from the station, and up to 25 horse-power, and among those who will be supplied from this station will be many requiring the hardest and most exacting duty. The use of the Sprague motors is extending outside of the United States. They have recently been sent to Canada and the Argentine Republic, and orders for a considerable number of machines have been received from Milan and Berlin. They are likewise to be introduced into England and France. Special machines are intended for the United States Naval Service. The Sprague Company are now building motors for the Electrical Accumulator Company of New York. Important contracts for overhead street line-work are to be closed. Entirely new systems of surface conduits will shortly be experimented upon. The company are now contemplating the transmission of large amounts of power from a central station, aggregating as much as 1,500 horse-power. In one sense, the most important electrical experiment ever performed has been undertaken by the Sprague Company. It will be remembered that during the latter half of the past year they were experimenting with motors on the Thirty-fourth Street Branch of the Elevated Railroad. On the 28th December these experiments were brought to a close for the time being, but they are now to be renewed on the most extensive scale. The company has engaged one of the best-known car builders in the country, and is completing its designs for a 28-ton motor car. This car is to be of special construction. It will be 42ft. long. The central space is to be devoted to passengers, and each end reserved for the engineer. The car is to have two trucks, each of which is to be equipped with two duplex motors of 75 horse-power each, operating upon 42in. driving wheels. The car will therefore have eight 42in. driving wheels, with four independent axles and two independent trucks, and the motors will have an aggregate capacity of nearly 300 horse-power. This is about 60 per cent. more than the present locomotives have when crowded to their utmost. All the weight of the car, 28 tons, is effective for tractive effort as against 15 tons of weight on the driving wheels of the present locomotives. Although the capacity of the motor car will be 60 per cent. greater than that of the locomotives, and its tractive weight about 90 per cent. more, the running strain on the structure is reduced about 20 per cent. because of the distribution of the weight over 42ft. instead of over a few feet as in the present locomotives. The work is to be pushed as rapidly as possible, and when finished the car will have ample capacity to handle a 120-ton train and make time."

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INCANDESCENT LAMP MANUFACTURE.—X.

BY J. SWINBURNE.

Flashing. (Continued.)

The actual apparatus for flashing may be divided into two parts, the flask and pumps and the electrical arrangements.

For flashing at the pressure of the air the apparatus is a suitable flask with a neck at the top for the insertion of the clip holding the carbon. A form is shown in Fig. 2. Coal gas

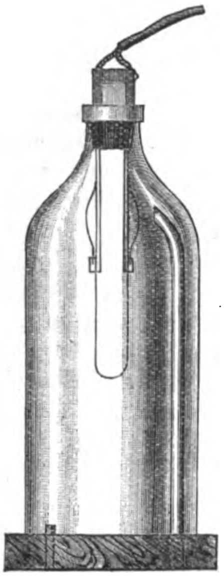

FIG. 2.

enters by the pipe cut off level with the wooden base, and the pipe brought up near the top is the exit. The gas is made to enter at the base, so that any air getting in at the top is not carried down over the carbon. When no clip is in, the top is kept closed to prevent escape of gas. The clip itself is shown in Fig. 3. It is difficult to design a thoroughly satisfactory

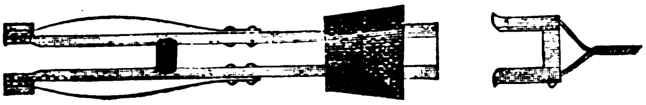

FIG. 3.

and cheap clip. The form shown is the best of a very large number tried. The two clips are made of two pieces of brass wire with one end flattened out to form a jaw. Steel springs are riveted on with brass end pieces to make the other jaws. In the middle of the bow of the springs little projections are fixed to the brass wire. On pressing the springs with the finger and thumb near the rivets they are brought against the projections and the jaws are opened; thus both jaws are opened by one action. The brass wires are made pointed at one end first, and are then heated and pushed through an india rubber cork. They are then passed through a small wooden head and electrically connected to two brass side pieces. A detachable clip with flexible wires is slipped over to make connection. Between the brass wires a cross-piece of bone or vulcanised fibre is fixed to keep them the right distance apart. The india rubber cork arrangement is only necessary for flashing in a vacuum; for flashing at the pressure of the air a wooden plug s better.

The gas may be passed through a vessel such as a Woulff's bottle, containing gasoline or crude benzol to enrich it. It is best to fill the bottle with loose cotton waste and not to make the gas bubble through the liquid.

For flashing in a vacuum the arrangement is different. In the first place, a pump driven by power is necessary, and must give a vacuum of about half an inch without demanding great attention. As pumps of this sort are also required in connection with the pump room, the description of them will be deferred till exhausting is discussed. A pump is needed for each flashing apparatus, as otherwise one operator is likely to interfere with another. The flask is made as shown in Fig. 4. Some care must be taken to get the neck right. If the slope is too small the rubber cork jams in under the pressure of the external air, and will not come out when the vacuum is broken and the external pressure removed. The flask is fastened to a wooden support. At the top of this support there is a brass clamp arrangement, which makes good electrical contact with the clip. This arrangement is stronger and more durable than

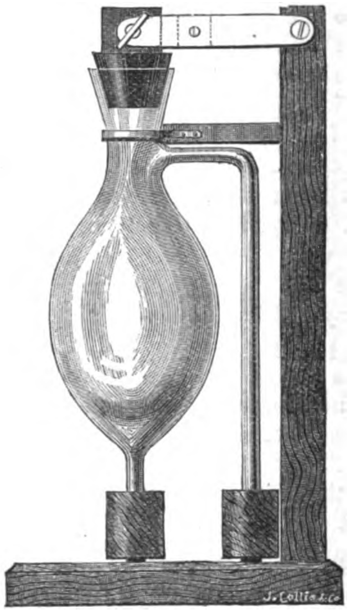

FIG. 4.

the flexible connection shown in Fig. 3. The flask has a tube at the bottom which fits tightly into a rubber cork, which connects it with the tube from the pump. This thick piece of rubber is used because a piece of rubber tubing, though it makes an airtight joint, is not so good, as the flask has often to be removed and cleaned.

Gas is admitted by the tube from the neck. Vaseline or lard is used to make the clip air tight. There is a tap in the vacuum and in the gas tube. When the carbon is put in gas is drawn through for a few moments and the supply turned off. The vacuum is then formed, and the carbon is flashed. It is sometimes a good plan to have supply taps arranged in parallel, so that one can be turned very nearly off so as to give a very small constant supply, while the other is used for blowing the air out of the flask at starting. The flask may be made without the tube from the neck. The lower tube is then connected with a three-way tap, which connects it to the pump or to the gas supply, or to neither. This should be so arranged that it cannot be left with the gas connected to the pump. The connections can be made with small composition pipe, such as that used for pneumatic bells. The joints should be soldered where possible, and when made to glass the rubber should be well greased and bound round with wire. Glass taps should not be used, as they always leak after a little use, and they are apt to break and give trouble. Well ground brass taps, such as those supplied by opticians are much better. Gutta percha tubing is often convenient for making vacuum connections.

A gauge is used to tell when the vacuum is good enough. It should be of the siphon, not of the barometer form. The barometer merely tells the difference of the pressure in the flask, and of that of atmosphere, which gives no information unless the pressure of the atmosphere is also known. A good siphon gauge is a little difficult to make, as the closed tube is apt to contain air, so that the gauge registers no pressure when there is a pressure of a quarter of an inch or so. This may be remedied by exhausting the gauge, and sealing it, and then working it about till there are no bubbles in the vacuum limb. A platinum wire may be sealed into the gauge and connected up in such a way that the circuit cannot be made through the carbon till the right degree of exhaustion is attained.

To go back to the 96-volt lamp again; it is now flashed

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down to the resistance mentioned on the table, which leaves the right margin for the small pieces which will be inserted in the sockets of the platinum wires, or covered with deposited carbon. It is generally best not to flash down to the final resistance at once; but there are several points to be considered. Flashing at the pressure of the air reduces the resistance of the carbon very rapidly, and is for that reason inaccurate. If the carbons are a great deal above the final resistance to begin with, it is best to flash them down at the pressure of the air first and to finish them in a vacuum after mounting. Carbons should come out of such a diameter and specific resistance that, after being once heated to a very high temperature, the resistance is nearly right. In flashing at atmospheric pressure a switch must be used which only allows the carbon to be in circuit for a second or two at a time, otherwise the deposit is bad. The shortness of time does not allow the carbon time for falling in specific resistance, so that pressure flashing alone is not enough. A lamp flashed to 100 ohms at the pressure of the air would, when run afterwards, fall in resistance, thus running bright. If the carbon is flashed much at the pressure of the air its diameter is slightly increased, and this throws the candle-power wrong. The carbons should therefore be flashed before being sorted out into batches. Thus, if the diameters of the carbons originally vary one per cent. each way, the gauge may be set to take long enough carbons to make 16 candle-power lamps even of the thinnest, and the instruments may be arranged to flash to, say, 210 ohms. Even the thick carbons will then do for 96 volts when shortened 20 per cent. The advantage of pressure flashing is its great rapidity.

Vacuum flashing can be used from the beginning; but it is very slow work if the resistances have to be altered much, as the process has to be done twice, as the carbons are slightly thickened.

If the carbons are very uniform in resistance to begin with, it is best not to flash at the pressure of the air at all, but to flash only after the carbon is mounted or fixed to the platinum wires. This method has two objections. One is that the carbon is softer before flashing, and is thus easily broken during mounting, and the second is that it is apt to be injured when the short-circuiting clip grips it. Flashing finally before mounting avoids these faults, but sometimes gives rise to inaccuracy.

A small inaccuracy in measuring the carbon or in resistance causes an error of only half in the electromotive force of the lamp. For instance, suppose a 15 candle-power lamp flashed to 52 ohms instead of 50, and having the right surface for 15 candles or 50 watts. Instead of taking 50 volts and 1 ampere, it will now take 51 volts and ·98 ampere, not 52 volts and 1 ampere. Similarly, if the resistance had been right, but the surface had been that of a 16 candle-power lamp, the volts would not be raised as the surface but as the square root of the surface. Thus, the 16 candle-power lamp needs 53·33 watts, which with 50 ohms is 51·66 volts and 1·033 ampere, not 53·33 volts and 1·06 ampere.

(To be continued.)

ON FROELICH'S THEORY OF COMPOUND DYNAMOS.*

BY KARL ZICKLER.

This paper contains an account of an experimental test of the validity of the formula

$$1 - M' = \frac{(1 - M_d') \, (1 - M_n')}{1 - M_d'.M_n'} \quad . \quad . \quad . \quad (1)$$

in the case of a Schuckert dynamo of constant E.M.F. (old type J L_3), and of some preliminary experimental investigations, required for the subsequent work, which were carried out by the author in conjunction with W. Peukert.

The quantities M', M_d', M_n', in formula (1) represent the ratios of the "effective magnetism" to its theoretical maximum value corresponding to an infinite value of the exciting current. These quantities therefore give the "magnetic saturation," M_d' with the series coils alone, M_n' with the shunt coils alone, and M' its value when the electro-magnets are excited by both sets of coils.

* *Zeitschrift für Electrotechnik*, Vol. V., Feb., 1887.

M' is known according to the formula when M_d' and M_n' are known, and the values of these have been determined by the preceding experiments.

Fig. 1 is a diagrammatic representation of the dynamo J L_3 with its shunt coils placed parallel to the armature. It can be made to represent a shunt-wound dynamo by simply connecting the leads of the external circuit to the brushes B,B', instead of to the binding screws K,K', attached to the poles.

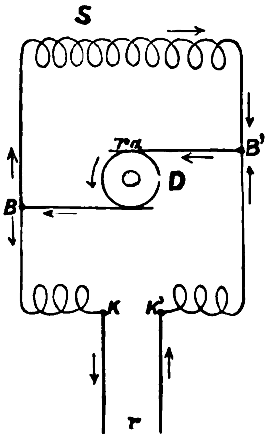

Fig. 1.

Frölich's researches raised the question as to the influence of the current in the armature on the magnetic field of the dynamo, and it has been considered by Dr. A. von Waltenhofen* in the case of series-wound dynamos, his investigations being founded on the results obtained by Hopkinson and by Deprez respectively, in one case with and in the other without a current in the armature. The results obtained by Deprez with a separately excited dynamo were unfortunately only partially applicable to the direct winding of the Schuckert machine, and quite inapplicable to the shunt winding, as the single light Schuckert machine (E L_1, old type) used by the author for exciting the electro-magnets was too weak to give a perceptible current through the high resistance of the shunt coils, and therefore a special investigation of this question became necessary. In the dynamo J L_3 used in the present experiments the resistance of the coils in series was found to be ·44 ohm, that of the shunt coils 69·69 ohms, and that of the armature ·21 ohm.

Results of Experiments with the Series Coils only in Circuit.

1. *With a current in the armature.*—The connection with the shunt was broken at the brush B (Fig. 1), so that the current now only flowed through the series coils, the electro-magnets being excited by this current only.

Tables I. and II. give the results obtained by varying the external resistance at two different speeds (v = number of revolutions per minute). The difference of potential between the terminals Δ, and (indirectly) the strength of the current C, were determined by measurement with a torsion galvanometer, and the external resistance r, the total resistance W, and the E.M.F. E_d were calculated from these two quantities combined with the known resistance (·44 + ·21 = ·65 ohm) of the machine.

The object of carrying out the experiments with two different speeds was to obtain an accurate mean determination of the constants a_d and b_d in the equation

$$C = \frac{1}{b_d}\left(\frac{v}{W} - a_d\right) \quad . \quad . \quad . \quad . \quad . \quad (2)$$

which holds for the rectilinear portion of Frölich's current curve.

When the current curves were constructed from the values of C and $\frac{v}{W}$, given in Tables I. and II., it was found that the rectilinear portion began at the ordinate 6, viz., with a current of 6 amperes, and that

For	$v = 1165$	$a_d = 59{\cdot}60$	$b_d = 8{\cdot}61$
	$v = 1270$	$a_d = 62{\cdot}00$	$b_d = 8{\cdot}63$
Means		$a_d = 60{\cdot}80$	$b_d = 8{\cdot}62.$

Now from the formula,

$$M_d = \frac{C}{a_d + b_d C} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The characteristic absolute value of the "effective mag-

* "Ueber die Charakteristik von Deprez und über den Einfluss der Ankerströme auf die Intensität des Magnetischen Feldes." By A. von Waltenhofen, in the *Zeitschrift für Electrotechnik*, 1885.

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TABLE I. (v=1165).

No.	C	Δ	r	W	E_d	$\frac{v}{W}$
1	18·3	86·6	4·73	5·38	98·4	216·3
2	14·6	81·5	5·58	6·23	91·0	186·9
3	12·0	78·3	6·52	7·17	86 1	162·4
4	9·9	74·8	7·55	8·20	81·2	142·0
5	7·8	66·9	8·58	9·23	72·0	126·2
6	6·8	63·9	9·39	10·04	68·3	116·0
7	5·2	52·3	10·05	10·70	55·7	108·8
8	4·5	50·4	11·20	11·85	53·3	98·3
9	3·84	47·4	12·34	12·99	49·9	89·7
10	3·00	42·5	14·16	14·81	44·5	78·6
11	1·45	28·5	19·65	20·30	29·4	57·3
12	0·80	20·8	26·00	26·65	21·3	43·7
13	0·55	17·8	32·36	33·01	18·2	35·2
14	0·37	15·0	40·54	41·19	15·2	28·2

TABLE II. (v=1270.)

No.	C	Δ	r	W	E_d	$\frac{v}{W}$
1	17·7	93·3	5·26	5·91	104·8	214·8
2	14·2	89·0	6·26	6·91	98·2	183·9
3	11·5	82·7	7·19	7·84	90·2	161·9
4	9·37	76·0	8·11	8·76	82·1	143·8
5	8·11	73·6	8·19	9·84	78·9	129·0
6	6·89	68·7	10·00	10·65	72·2	119·2
7	4·68	56·9	12·09	12·74	59·6	99·7
8	4·00	53·9	13·47	14·12	56·5	89·9
9	3·50	50·0	14·28	14·93	52·3	85·1
10	3 00	47·0	15·66	16·31	49·0	77·8
11	1·56	33·0	21·15	21·80	34·0	58·2
12	0·97	25·5	26·28	26·93	26·1	47·1
13	0·69	21·7	31·44	32·09	22·1	39·5
14	0·41	18·5	45·12	45·77	18·8	27·7

TABLE III.

(v=1165)				(v=1270.)			
C	E_d'	C	E_d'	C	E_d'	C	E_d'
9·70	98·8	3·10	60·7	8·90	106·7	3·70	71·7
8·56	98·0	2·48	54·1	8·28	104·0	2·75	58·1
6·80	89·1	1·73	43·6	7·50	101·2	2·40	54·5
5·50	82·3	1·16	35·0	6·25	94·8	1·94	48·2
4·50	73·7	0·76	28·0	5·20	86·7	0·72	28·8
3·73	67·4	0·33	19·0	4·34	77·8	0·45	22·8

netism" reaches its theoretical maximum $\overline{M_d}$ for $C=\infty$, and therefore this may be written

$$\overline{M_d}=\frac{1}{b}=f_d \quad . \quad . \quad . \quad . \quad (4)$$

and in the present case its value is $1/8{\cdot}62=0{\cdot}1160$.

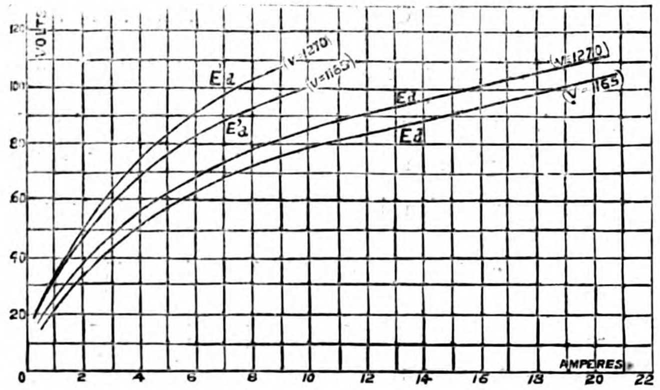


FIG. 2.

Fig. 2 shows the characteristic curves (curves E_d) corresponding to the two different speeds, which express the relation between the E.M.F. E_d and the exciting current C, and which satisfy the equation

$$E_d=\frac{v\,C}{a_d+b_d C} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

2. *Without a Current in the Armature.*—The electro-magnets were excited by means of a Schuckert machine EL_1, which, unfortunately, could not produce an exciting current greater than 10 amperes. The E.M.F. E_d', reduced in the armature by the exciting current C, was measured by means of a torsion galvanometer, constructed for use with weak currents. Table III. gives the values obtained for C and E_d', and from these the curves E_d' in Fig. 2 were constructed, satisfying the equation

$$E_d'=\frac{v\,C}{a_d'+b_d'C} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

A comparison of these curves with the curves E_d obtained in the former case shows very clearly the effect of the current in the armature upon the intensity of the magnetic field. For example, with a current C of 8 amperes, its mean value (at the two speeds) amounts to 23·5 per cent.

The values obtained for the constants a_d' and b_d' were

$v=1165$	$a_d'=31{\cdot}73$	$b_d'=8{\cdot}33$
$v=1270$	$a_d'=34{\cdot}76$	$b_d'=7{\cdot}99$
Means	$a_d'=33{\cdot}25$	$b_d'=8{\cdot}16$

giving for the maximum value of the "effective magnetism"

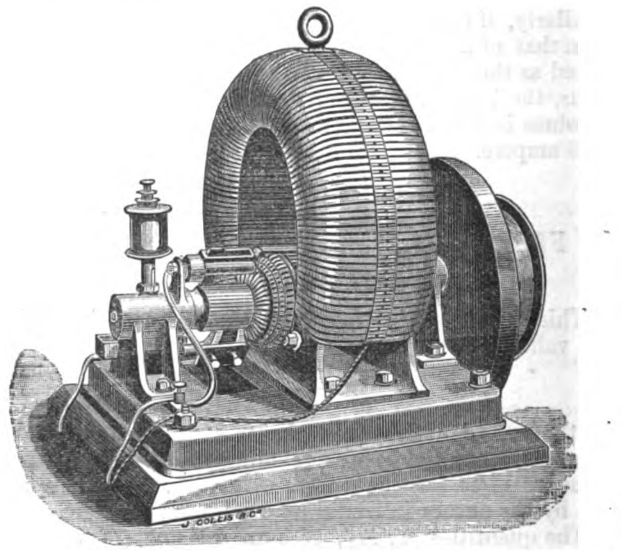
$$\frac{1}{b_d'}=f_d'=0{\cdot}1225.$$

The comparison of this value with the value 0·1160 obtained in the former case shows that with an infinite exciting current the effect of the current in the armature would be only 5·3 per cent., which differs considerably from the result actually obtained with a finite current.

(To be continued.)

SWAN'S DYNAMO.

We have often had occasion to visit Mr. Swan, and to see the various experiments with his well-known incandescent lamps, safety lamps, &c., being carried out in his laboratory. It may be news to many to whom the name of Swan is a household word to know that he has devoted considerable attention not only to the perfecting of lamps but also to the construction of dynamos, and we now illustrate and briefly describe an experimental dynamo that has been running for some time to supply the current required at his own house.



The Swan Dynamo.

The dynamo was designed in May, 1885, with the object of obtaining a more economical production of electricity for lighting Mr. Swan's house, a Crossley gas engine of 3½ horse-power (nominal) and somewhat dear gas being employed to generate the motive power. The core of the field-magnet is a ring broken only by the gap in which the armature revolves.

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It is forged, in one piece, of the best Swedish iron, and is carefully annealed. The field-magnet coils are built up of flat sections, composed of ribbon wire. The flat coils, or sections, were formed by winding the ribbon on wooden cores of the same cross section as the field-magnet, and, after being saturated with solution of lac to cement the convolutions together, the wood core was removed, and the coil slipped into its position on the iron ring. The sectional coils are all united in series. The pole pieces are partly formed by the ring itself, and partly by two pieces of iron added, which form the upper halves of the pole-pieces.

The armature is built up of 270 annular discs of best Swedish sheet iron. These are carefully annealed, and are separated by thin paper. Solidity is given to the structure of the armature by means of 2¼in. thick outer rings and three binding bolts. A fly-wheel in one piece, with the pulley (22in. diameter), is fixed on the armature axle, to lessen the variations of its speed, due to the variable speed of the gas engine.

The machine measures over all 2ft. 9½in. in height, and covers 2ft. 2in. by 3ft. floor space. At 800 revolutions it gives 55 volts and 50 amperes, equivalent to 2·75 B. T. units, or nearly 3·7 E.H.P. The magnets are shunt-wound, and perfect regulation is secured by the addition of some secondary batteries. The weight of magnetised iron is 500lb., and of copper 340lb., with a total weight of 1,111lb. These figures represent an output of 2·47 watts per lb. of dead weight, and 8·08 watts per lb. of copper.

The field-magnets weigh 350lb., and are wound with 3·72 miles of wire, having an exciting power equivalent to 11,025 ampere turns. The wire is of ribbon shape, measuring $295 \times 17{\cdot}75$ units, or in section ·005236 square inch. The total resistance of the coils is 36 ohms, and the exciting current 1·5 ampere, showing a loss of 54 watts. The density of the current in these coils is very low, being only 288 amperes per square inch.

The armature is of the Pacinotti type. The ring has a radial depth of 2in., axial length (over all) 9in., diameter $8\frac{5}{16}$in. It is wound with 66·6 yards of wire, weighing 22lbs. The sectional area of this wire is ·01274 square inch, and its resistance ·054 ohm. The current density is 3,924 amperes per square inch, and the watts lost amount to 135. The weight of iron in the armature is 75lbs., showing an output of 125 watts per lb. of armature copper, and ·735 volt per yard. The commutator has 40 pieces. The peripheral speed of armature amounts to only 1,740ft. per minute. The bearings of gun-metal are 5in. in length.

The machine has fully come up to Mr. Swan's expectations, and has been running daily for the last twelve months without the slightest hitch.

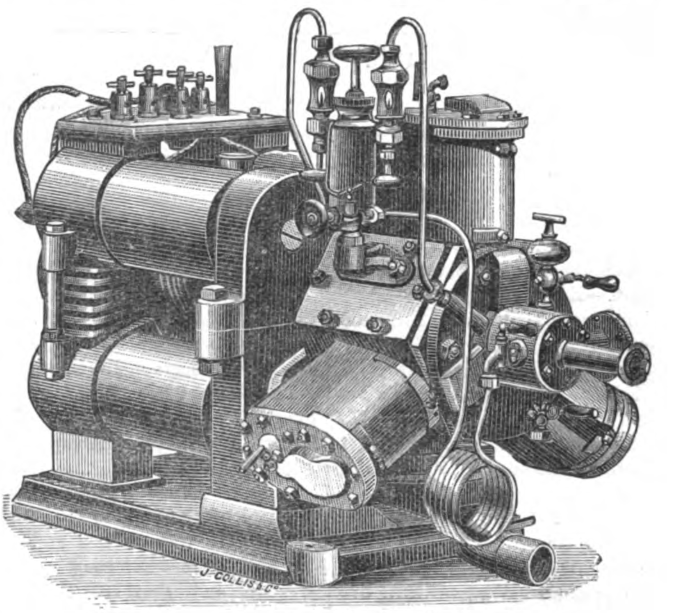
LITERATURE.

Magnetism and Electricity, for the Use of Students in Schools and Science Classes. By H. C. Tarn. [W. and R. Chambers.]

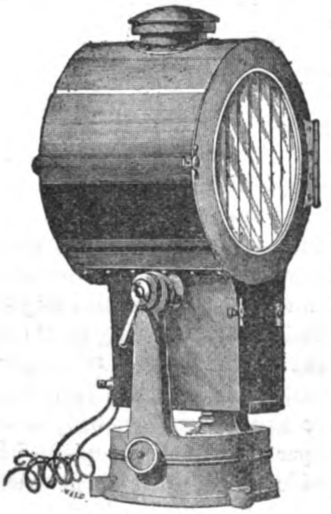
This little book is one of a numerous class written more especially for young students. The author has no doubt read books, but as for having any knowledge of the subject, in the modern acceptation of the term, it is conspicuous by its absence. It may be that the theory of the earth being a huge reservoir is still held by the majority of eminent electricians, and the author may appeal to them for support, but we shall be content to rest with the minority—if minority it be—who do not agree that electricity is drawn to or pumped from "the great earth-reservoir, whose capacity for the disposal of electric charges is practically unlimited." Mr. Tarn's book may be the best arranged of all school books, his pepper-box distribution of black type may have untold value, his illustrations may be numerous and good—yet we must emphatically protest against the use of books which teach what the student must unlearn, and leave untaught what the student will have to learn. The concluding paragraph of the book says:—"A thorough knowledge of what this little book contains will be a safe passport to a first class in any elementary paper that may be set by the Department." This statement may be true; if it is we cannot say much for a Department which accepts answers about "induction" which show no shadow of a sign of knowledge about the induction circuit.

A PORTABLE ELECTRIC LIGHT APPARATUS.

We have been favoured with a description and photograph to illustrate specially designed electric light apparatus for ship use in narrow waterways. The plant consists of a Brotherhood 3-cylinder engine, a Victoria dynamo, and a Brush Company's projector. This plant is useful wherever a light and portable apparatus is required. The dynamo differs from the usual type of Victoria dynamo of the Brush Company in having single-ended magnets, instead of the form with two coils on each bar. The pole-pieces are made to encircle the two sides and the periphery as usual. This arrangement is adopted mainly to economise space. The speed is 750 revolutions per minute, the E.M.F. being 65 volts, and the current 40 to 60 amperes, according to requirements. The dynamo is compound-wound. The engine is the latest type of Brotherhood, having 3in. cylinder and 4in. stroke, steam pressure 90lbs. One of the bearings is projected between the magnets of the dynamo, and forms the bearing also of the dynamo shaft. The two shafts are, in fact, continuous, the armature being overhung, having no outside bearing. The weight of the engine bedplate and dynamo is 7cwt. The following are the over all dimensions of the engine and dynamo:—Length 2ft. 10in., width 1ft. 8½in., height 1ft. 10¼in.



Brotherhood Engine with Victoria Dynamo.



Brush Projector.

The arc lamp is one of the new Victoria automatic focussing search lamps, recently introduced by the Brush Company, contained in one of their "ahead" lanterns or projectors provided with a "Chance" mirror (16in.). The weight of the ahead lantern complete is 2cwt., making the whole of the plate 9cwt. In place of the usual door or front of plain glass, the lantern has a compound dispersing lens, which converts the parallel beam into a thin wedge of light, practically parallel vertically. This is said to have a great advantage over the usual form of (parabolic) reflectors which send out a cone of light, as it flattens the beam and distributes the light in an economical manner over the area which it is desired to illuminate. The fact that the lamp is quite automatic enables the person who is directing the projector to devote the whole of his attention to it. The lamp is exceedingly simple, consisting mainly of a core and solenoid operating the carbons by a cord passing over a suitable pulley.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CITY NOTES.

Our readers will find these Notes separate from the more technical and News Notes, and placed together after reports of meetings.

CONTENTS.

Notes ... 363
Incandescent Lamp Manufacture.—X. By J. Swinburne. Illustrated ... 368
On Frölich's Theory of Compound Dynamos. By Karl Zickler. Illustrated ... 369
Swan's Dynamo. Illustrated .. 370
Literature ... 371
A Portable Electric Light Apparatus. Illustrated ... 371
TELEPHONIC INVESTIGATIONS. 372
Correspondence ... 373
Telegraphic Communication by Cable Lines ... 374
Electric Light Installation at the Hadfield Mills. Illustrated ... 376
Applications of Electricity to Mining Operations. By F. J. Rowan, C.E. ... 377
Duplex Telephony. By Dr. A. M. Rosebrugh. Illus ... 378
Society of Telegraph-Engineers and Electricians ... 380
Physical Society ... 381
Electric Lighting Act Amendment Bill ... 382
Companies' Meetings—
Telephone Company of Egypt 383
Telegraph Construction and Maintenance Company ... 383
Western and Brazilian Telegraph Company ... 384
City Notes, &c. ... 384
Companies' Share List ... 384

TELEPHONIC INVESTIGATIONS.

A fresh proof of the never failing interest which any discussion of microphonic or telephonic phenomena invariably arouses has just been furnished at the SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS, where large audiences have assembled at three successive meetings to hear an account and criticisms thereon of some "Telephonic Investigations" by Prof. SILVANUS THOMPSON. These investigations proved to be neither startlingly novel nor indisputably useful; but they served to attract an exceptional number of people and to evoke an inexhaustible supply of comment. The whole session might, without the least difficulty, be filled up by discussing points of far less importance than those raised in Prof. THOMPSON'S paper. But in reality, if the discussion took a more academic and less practical turn than the lecturer had intended, nobody is to blame for it but himself. His paper was largely occupied with theoretical and speculative considerations, upon which much division of opinion prevails; and for lack of anything better to lay hold of the opposing partisans did friendly battle each in defence of his own pet conclusions. We are not much concerned with these conclusions here at present; all that we need say about them is that the lengthened discussion they have just undergone has certainly advanced matters in the right direction, bringing us measurably nearer the true understanding of the microphonic action upon which practical telephony is so greatly dependent.

But this, we imagine, was not the object of the paper under discussion. As stated by its author, the object was, first, to exhibit a variety of telephonic apparatus invented by himself; secondly, to describe the experimental stages which had led him to these inventions; and, lastly, to secure the benefit of having his ideas publicly criticised by competent experts. We sincerely hope that he obtained what he desired; for in that case we may expect some valuable practical result to come of it, which was by no means evident from the paper itself. Unless we are to regard the valve telephone transmitter and its receiver as perfected novelties—which few persons outside the law courts will admit them to be—we are left pretty much where we were in respect to practical improvements in telephony. One of the principal, if not the principal, proposition insisted upon by the lecturer was that the existing difficulties, whatever they may be, of telephonic communication could be overcome by strong transmitters and weak receivers,—or, to put it differently, by employing more powerful currents for speaking, and less sensitive appliances for hearing—remained unproved by any practical or even theoretical demonstration. A great deal of pains had been taken in contriving, and much time spent in describing, devices for increasing the outgoing current; but here the matter ended. Everybody expected that the receiver adapted for such currents would be forthcoming; but it was not; and, so far as we know, the problem is as far off being solved as ever. Perhaps Prof. THOMPSON knows otherwise—we hope he does; but in that case his reticence before an audience whom he professed to take into confidence is somewhat inexplicable.

Although, however, there were no features of special novelty in the apparatus submitted by Prof. THOMPSON, and, although his experimental disclosures stopped short just where we expected them to go on, his paper was, in many respects, a remarkable and valuable contribution to the scientific literature of telephony. His classification of all the known varieties of Transmitters and Receivers, his researches in respect to the microphonic contacts, his largely increased list of materials suitable for Transmitters, his suggestive remarks upon the construction of Transformers, and his exposition of the principle of the dynamo as applied to the telephone—though this latter was questioned by a high authority—will all be of use to future investigators, and well deserved the praise bestowed on them by his audience. But in listening to him it was impossible to avoid at times the impression that he held a brief for something or somebody. This suspicion was blurted out by one member, more candid than polite, early in the discussion; and although he was severely handled for his audacity, he had, it must be confessed, plenty of ground to go upon. Over and over again the learned professor betrayed the fact that he was defending innovation rather than propounding scientific truth, and he repeatedly assailed some generally accepted theories with a vehemence wholly unaccountable except on the supposition that, to use his own phrase, he was thinking more of the "commercial articles," whose "points of novelty are solely of an industrial sort"—that is to say, of the legal sort—than of any scientific discovery worthy the audience he was addressing. For example, he says that the problem he had to solve was "to find a form of instrument which, while admitting of more powerful currents being used . . . . would neither spark at the contacts, nor necessarily *require the intervention of a diaphragm to collect the sound waves.*" Why, we may ask, was the clause we have italicised a part of the problem to be solved? It is a legal problem, but it is not a scientific one by any means. In reality we can often dispense with what is popularly called the diaphragm; but we can never dispense with the diaphragm's functions, call it by what name we please. His strong language upon the judicial dictum as to "make" and "break"

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telephony points to the same conclusion; and his remarks under the head of "Intermittence in Vibrations" are, we submit, so much scientific dust intended for legal eyes. Nobody asserts that "discontinuous electric impulses cannot set up and maintain a continuous vibration." What is generally asserted is that continuous vibrations obtained in such a way are not adapted to the perfect reproduction of articulate speech. We are not finding fault with Prof. THOMPSON on this accouut. He has a right to use his opportunties as best he can, and this was one of them. His object has our entire sympathy; but we cannot help thinking that its attainment would be more likely to be furthered on occasions like these by his being perfectly candid about it.

Turning now to the more ostensible purpose of Prof. THOMPSON'S paper, the chief conflict of opinion arose, as was to be expected, on Mr. PREECE'S flat denial of the fundamental principle on which the author had been working. Mr. PREECE, however, in defending things as they are—at all events, as they are at the Post Office—and in showing how admirable telephony might be if all the conditions were as correct as they ought to be, laid himself open to the retort that it was the business of inventors to make good the defects of existing lines, not to construct better lines. Nevertheless, there was much that this practical telegraph engineer said concerning the laws regulating the speed of telegraphic signalling which are applicable equally to telephonic signalling, and which account for the failures the latter often incur through these laws being ignored altogether when telephonic lines are erected. Mr. PREECE evidently treated Prof. THOMPSON'S contrivance for transmitting strong currents as if designed mainly for "long-range telephony;" and in this he was justified by the language of the paper itself, notably by the paragraph with which it concluded. Prof. HUGHES, on the other hand, regarded the suggestion as intended to overcome inductive effects from neighbouring wires; and, discussing it from this point of view, dismissed it with the remark that "we cannot preserve the tones we desire, and at the same time reject those we do not desire." Here was the opportunity for Prof. THOMPSON to have adduced proof or evidence of some kind that Prof. HUGHES, as well as Mr. PREECE, was wrong. But, as we have already stated, he failed to do this; and we are reluctantly compelled to say that the one most important problem in practical telephony worth discussing remains just where it was before Prof. THOMPSON made public his "Investigations."

CORRESPONDENCE.

SELF-INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your issue of Jan. 21, 1887, a criticism on my use of the term "self-induction." I think I have been misinterpreted. I certainly did not refer to the "Foucault" disturbance, as stated.

The difference of potential obtainable at the terminals of an armature is determined by the following factors:—

Let E be the difference of potential proper obtained by the inductive influence of the field upon the armature, &c.

Let R be the resistance of the armature in ohms,

C the current flowing through the armature coils, and X a constant depending on the type of armature. The length of the inducto-receptive wire, in short, a ~~constant of self~~ induction.

Then, when no current is flowing in the armature, the difference of potential = E; but, when any current is flowing, the difference of potential at the armature terminals is less than E, being equal to difference of potential = E – C (R + X). Now, if X = 0 the difference of potential = E – C R, as is well known.

What I intended to state in my note to the *Electrical Engineer* of New York was that the *counter E.M.F.*, or self-induction, in the armature wires of my alternate current dynamo was fractionally 0, and that the difference of potential of the dynamo varied from a constant value only by the amount necessarily lost in (C R) urging the current through the ohmic resistance of the armature.

To illustrate by example, the difference of potential obtained at the armature terminals of my dynamo remains nearly constant.

In a Siemens alternate current dynamo that I have experimented with under similar conditions, the difference of potential varied from 1,800 volts, when running free, to 600 volts when running at full load. In other words, the counter E.M.F. or self-induction developed by the current in the armature coils and the difference of potential absorbed by urging the current through the armature resistance reduced the difference of potential from 1,800 volts to 600 volts.

It seems to me to be immaterial whether the term self-induction be expressed as induced resistance or counter E.M.F.

—Yours, &c., WILLIAM STANLEY, JUN.

Great Barrington, Mass., Feb. 11, 1886.

[Our note of January 21st, referred to the following remark of Mr. Stanley:—"It was found upon trial that the iron core instead of heating from self-induction reduced the self-induction to a practical zero." With regard to the latter part of this sentence, paradoxical as it appears, we may state that we are aware of the possibility of reducing self-induction, under certain given conditions, by *increasing* the mass of iron in the core of a given coil.—ED. *E.*]

REPORTS OF INSTALLATION AT THE PRINCE OF WALES THEATRE, COVENTRY-STREET, W.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have great pleasure in again placing before you for publication in your journal the third year's report of the working of the above installation.

The plant comprises a 12 horse-power Clerk gas engine, manufactured by L. Sterne and Co., one Siemens D1 dynamo, an E.P.S. battery of 53 cells, and 360 Swan lamps, 108 volts, 16 candle-power.

In placing this report before your readers we must candidly express the great satisfaction the gas engine has given us ever since its erection. During the past year it has run 2,895 hours. The only repairs the engine has had since erection is the annual cleaning of the water jacket on account of the deposit of lime, which we find comes from the circulating water. The other repairs have been trifling.

The slide now working was put in in June, 1885, and has not been refaced. The bearings have not been touched; the latter, no doubt, is helped by using nothing else than castor oil, which we consider best for heavy bearings. The engine, besides running the dynamo, also drives the pumps for the hydraulic machinery for the iron fire-proof curtain on the stage and for the hydraulic lift.

The dynamo has this year been more satisfactory than last. Only six pairs of brushes used, and it has only been turned up once, and has not given any trouble whatever.

With regard to the accumulators, the glass cells which were put in about 18 months ago are still working well. Only seven of them have had to be taken out and the plates straightened, although put to very heavy work; the remainder are in capital condition. In October last 24 of the old teak boxes were taken away and replaced by 48 glass cells. These have all worked admirably, being now in splendid condition, and showing a fine dark chocolate colour on the positive plates. The negative plates only show a very slight appearance of blistering.

The lamp renewals show a larger average than before, owing greatly to a number of old lamps giving out their life. There are several lamps still running that were put up when the theatre was built, and have stood the greatest work, but are still working, they having run over 3,500 hours.

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During the year we erected a batten with 12 lamps under the painting room floor, which overlaps the stage, and eight lamps under the stage, gas being found too hot, and the men being unable to work, there being very little ventilation. These lamps are greatly appreciated by those working under them. The renewals are as follows :—Loops 31, accident 21, filaments 70; total 122. Of these we have been able to repair 28 lamps with broken loops.

The theatre was closed three weeks in July, but there have been 46 extra morning performances.

The subjoined is an abbreviated account of the working expenses :—

Electrician and assistant	£221	2	6
Gas used by engine	189	4	0
Lamps	25	5	0
Oil for engine, shafting, dynamo, and pumps	8	8	0
Waste for above and sundry other purposes	1	15	0
Repairs of brushes	1	17	6
Lamp shades	0	9	6
Sundries	4	0	0
	£452	1	6
Repairs—			
Accumulators	£186	0	0
Dynamo	0	12	0
Engine	4	4	0
Belts	4	10	0
	£195	6	0
Total for working	£452	1	6
Total for repairs	195	6	0
	£647	7	6
Total for two previous years	£1,131	5	10
Grand total for three years	1,778	13	4

Certificate from E. Bruce, Esq.

Prince of Wales Theatre,
March 2nd, 1887.

Another year is now completed, making the third since the electric light was installed at my theatre, and again I have nothing but praise to give to those concerned for its very successful working; in no instance has it failed. I have made further use of it on the stage for lighting effects in "Alice in Wonderland," and am thoroughly satisfied at the results obtained.—Signed, EDGAR BRUCE.

—Yours, &c., ERNEST LOWER BERRY
(for Berry and Co.).

AERIAL WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will any of your readers kindly give me a formula for the strain of a wire with points of support at same level in terms of *dip*, *length of span*, and *weight of wire per yard?*—Yours, &c., AN ENQUIRER.

Feb. 28th, 1887.

THE RECENT EARTHQUAKE IN SOUTHERN FRANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On Saturday, the 19th February, at 3:15 a.m., a sudden electrical disturbance occurred, dropping a great number of indicators on our central switch-board, besides ringing several bells. The currents appeared to affect wires running east and west only, and fluctuated considerably in their intensity, lasting about fifteen minutes.

This phenomena occurred some three hours before the first undulatory movement of the earth was felt at Nice, and two days prior to an eclipse of the sun. As reliable information on the subject of "earth currents" is not extensive—although we know they are identical with solar activity—it would be interesting to know whether similar disturbances were felt in other parts of England or on our submarine lines, and whether this coincidence of electrical disturbance, solar eclipse, and earthquake have not some close relationship which may, perhaps, add light to this important subject.—Yours, &c.,

T. SCOTT ANDERSON.

Western Counties and South Wales Telephone Company, Plymouth, March 1st, 1887.

MOTORS.

The following is a copy of a letter sent by Mr. Mordey to the editor of the *Electrical World* (New York) :—

"SIR: In a recent number you published a letter from Mr. F. J. Sprague, which has placed me in a rather difficult position. It seems such an extraordinary thing to issue a challenge on a matter which has no bearing whatever upon the points at issue, and which, even if accepted, could lead to no useful result, that I do not feel sure that the letter is intended to be taken seriously. If, therefore, in treating it seriously I am acting under a misapprehension, I must plead in extenuation my desire to show no want of respect to Mr. Sprague, whose energy and skill in applying electricity to purposes of locomotion are worthy of admiration.

"Mr. Sprague accuses me of having 'joined the hunt and raised the cry against the originality of his work,' but he does not quote the passages or the statements to which he objects, nor does he endeavour in any way to show in what I am mistaken. I find that my only mention of Mr. Sprague's work was in an article in the (London) *Electrical Review* of December 24th, when I referred to two points which had been described respectively as Mr. Sprague's 'main principle,' and his 'law of winding,' and pointed out that they were not new. The 'main principle' was that of regulation by inverse variation of field excitation, which, of course, is the idea underlying the well-known differential winding of Profs. Ayrton and Perry. The 'law' referred to is the following :—'The number of turns in the shunt coil must bear the same ratio to the number in the series coil as the resistance of the shunt coil bears to the sum of the resistance of the series coil and the armature.'

"This so-called law of differential winding is a development by Prof. Silvanus Thompson of Profs. Ayrton and Perry's system, and is given in his 'Dynamo-electric Machinery,' first edition, p. 367.

"These, then, are the only questions on which I have 'joined the hunt and raised the cry' against Mr. Sprague, and—to use a figure from the same source—it is across this scent that he has 'drawn a red herring' in the shape of a challenge, which, as I have already intimated, has nothing to do with the case.

"Mr. Sprague has not time, he says, to enter into any discussion whatever of the questions that have been raised. It certainly seems to me that it would have taken him less time to give the reasons—whatever they may be—on which he bases his objections to the opinion of his critics than to write his remarkable letter; and I cannot but think that time was not the only thing of which his supply was insufficient.

"As to the challenge itself—to build two motors from designs dating back not less than five years—I feel that by meeting Mr. Sprague's wishes in this matter I should only be making a demand on his time which would prevent him from devoting himself to the real issue.—Yours, &c., "W. M. MORDEY.

"London, February 28, 1887."

TELEGRAPHIC COMMUNICATION BY CABLE LINES.

The official organ of the Imperial Federation League has an article which it terms "Revelations about the Telegraphic Route to Australia," and which causes us to ask who is responsible for articles inserted in this publication? Our impression, rightly or wrongly, is that Mr. Arnold Forster occupies the responsible post of editor. If this be so, none know better than the editor how easy it is to criticise adversely, how easy it is to pull to pieces, and how extremely difficult it is to construct *de novo*. Any man can find fault; but what will he suggest in the place of that which he criticises, of course taking all the conditions into consideration? No instrument yet

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designed by man is perfect, hence it would be well to expect cable lines occasionally to suffer from the ills that human concerns are subject to. But at the same time, it must be admitted—nay, we claim it without question—that of all the scientific appliances called to the aid of man electricity as applied to cable work has served him most faithfully and more perfectly than any other.

We have inquired into the statements made by the writer of the article, and find that the list of cable interruptions, although in some respects inaccurate, is substantially correct, but it appears to us manifestly unfair that the existing cable service to Australia should be judged by the breakdowns that occurred before it was fully organised and duplicated, it being well understood that a single line of cables cannot be considered a reliable communication. Moreover, the first interruption given (in 1872), and which represents nearly one-fourth of the total period of interruptions, happened before the communication was completely established and the cable handed over by the contractors, consequently it cannot fairly be taken into account.

It was the knowledge that the communication was liable to frequent interruption that induced the colonies of Victoria, New South Wales, South Australia, and Western Australia to give the Eastern Extension Company an annual subsidy of £32,400 to duplicate their system between Penang and Port Darwin, which duplication was carried out in January, 1880; but the route then followed differed materially from the original course by taking the cable direct from Singapore to Banjoewangie (the extreme eastern end of Java), and by so doing the necessity for transmitting the telegrams over the Java Government land lines, where interruptions and numerous errors had occurred, was got rid of, and the unsatisfactory ground between Singapore and Java was also avoided.

Since the system was duplicated—that is, seven years ago—the communication between the Australasian colonies and the rest of the world has been totally interrupted for only a few days, and this occurred in 1883, through circumstances of a most exceptional nature, not likely to recur. The existing service cannot, therefore, be open to the sweeping charges made against it by the writer of the article under review.

With regard to the land connection across Australia, we can well believe that the difficulties of maintenance are very great, and that the want of an alternative land line route is much felt in the colonies. This can apparently be easily and speedily supplied, as we are given to understand that the Eastern Extension Company some time ago offered, and are still prepared, to lay a cable at their own expense, between Normanton, the terminus of the Queensland telegraphs, and the River Roper, so as to form a junction between the telegraph systems of the Queensland and South Australian Governments, but for some unexplained reason the Queensland Government have so far not accepted the offer.

The article in *Imperial Federation* referred to above is as follows:—

A few months ago we called attention to an official statement made in the House of Commons that telegraphic communication with the Australian colonies had been dependent solely upon the line through Russia only once during the six years from 1881 to 1886. The deduction which every one was expected to draw from this was that interruptions were of the rarest occurrence, and that an alternative route was therefore unnecessary. Perhaps the following record of the cable interruptions on the Australian route between the years 1872 and 1883 (we are unable to furnish later figures) will show that it is living in a fool's paradise to believe that breakdowns are few and far between. Indeed, it is only the fact of the line being in duplicate that has saved the communication from being constantly defective. We are unable at present to lay our hands upon the dates when the two lines between Singapore and Port Darwin were laid down, but we shall endeavour to discover this for the benefit of the public, who ought not to be allowed to remain in doubt as to the exact measure of their security. It is, however, a sufficiently serious matter when we find that in the twelve years under review there have been no less than thirty breakdowns, totalling up to a period of about 540 days, or eighteen months, during which some portion of the direct cable route to Australia was unavailable. We now give the list, leaving our readers to form their own opinion as to the entire trustworthiness of cable communication with Port Darwin, the only point, be it remembered, in Australia which is connected with any other continent by cable.

Cable Interruptions on the Australian Route, 1872—1883.

	When Interrupted.	When Restored.	Where Between.
1872.	June 22.	Oct. 20.	Port Darwin and Banjoewangie.
1873.	Feb. 21.	Feb. 24.	Land line between Boczki and Banjoewangie.
	March 31.	April 2.	Batavia and Singapore.
	May 12.	May 26.	Penang and Madras.
	July 13.	July 13.	Land line 30 miles from Banjoewangie.
	Nov. 20.	Nov. 23.	Singapore and Penang.
1874.	May 20.	May 31.	Batavia and Singapore.
	Aug. 13.	Aug. 15.	Ditto.
	Aug. 16.	Aug. 23.	Ditto.
	Dec. 10.	Dec. 29.	Ditto.
Floating station was established sixteen miles from Batavia, with daily steam communication to Singapore, on Dec. 18th.			
1875.	Sept. 2.	Sept. 16.	Batavia and Singapore.
	Nov. 5.	Nov. 8.	Ditto.
	Nov. 15.	Dec. 24.	Penang and Madras.
1876.	March 28.	Aug. 24.	Ditto.
	April 24.	Aug. 7.	Port Darwin and Java.
	Oct. 22.	Nov. 30.	Batavia and Singapore.
1877.	Feb. 26.	March 2.	Ditto.
	July 15.	July 17.	Singapore and Penang.
	Sept. 26.	Oct. 13.	Batavia and Singapore.
	Oct. 19.	Oct. 31.	Singapore and Penang.
	Nov. 8.	Dec. 15.	Port Darwin and Banjoewangie.
1878.	Jan. 22.	Feb. 3.	Batavia and Singapore.
	March 11.	March 13.	Land line between Sitoebondo and Surabaya.
	Sept. 26.	Oct. 5.	Port Darwin and Banjoewangie.
1879.	May 29.	May 30.	Ditto.
	July 4.	July 24.	Ditto.
1883.	March 5.	March 7.	Ditto.
	March 9.	March 16.	Ditto.
	April 6.	April 9.	Ditto.
	Oct. 22.	April 26.	Ditto.

Supposing that cable communication between Port Darwin and London were absolutely perfect, and secured against the faintest possibility of a breakdown, there would still be cause for the gravest anxiety, should it be a matter of urgency to send telegraphic despatches to our great Australian colonies.

It must be remembered that the whole continent of Australia has to be traversed by a single line before that network of telegraphs in the south is reached, where total interruption is a practical impossibility. The nearest telegraph station in Queensland is several hundred miles from the trans-Continental line over which every message from Europe to Adelaide, Melbourne, Sydney, Brisbane, and New Zealand has to pass.

It is sometimes supposed that a land wire is perfectly safe. So far as the Queen's enemies are concerned this is true; but there are natural forces which give more trouble than hostile grappling-irons. Between Port Darwin in the north and Port Augusta, where the branches diverge from the trunk line in the south, there have been in the twelve years from 1872 to 1883 inclusive one hundred separate occasions on which communication has been interrupted, covering a period of two hundred and one days.

What, then, is the use of relying upon duplicate cables and security of communication by sea, so long as these interruptions take place on the land? Some of the stations are very long distances apart, and priceless time might elapse in conveying some urgent message across the hiatus caused by a breakdown. Is it not the height of infatuated folly to lean upon the fancied safeguard of this trans-Continental wire, which has so often failed us? It is admitted on all hands that *immediate* notice of a declaration of war would be a necessity if the shipping in Australian waters is to be confined to port, and the harbours are to be protected against attack. And yet the only means of sending prompt information to a single port in Australia or New Zealand hangs upon the immunity from damage of a single line of telegraph, which can only show for a testimonial the record of a hundred interruptions in twelve years. The list is too long for us to publish the whole of it; but we append a summary, which shows that the breakdowns can be reckoned upon to occur in every year, to a greater or less extent.

Interruptions on the Telegraphic Line between Port Darwin and Port Augusta.

Year.	Number of times broken.	Total length of interruptions.	Year.	Number of times broken.	Total length of interruptions.
1872	2	6 days.	1878	19	38½ days.
1873	7	18 days.	1879	13	22 days.
1874	8	20 days.	1880	2	2 days.
1875	8	17½ days.	1881	5	5½ days.
1876	9	25 days.	1882	5	6½ days.
1877	17	34 days.	1883	5	6 days.

We hardly know where to look for comfort—whether the cables

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or the land line are most to be trusted. But surely the case is strong enough to be taken in hand without delay. Many millions sterling are hazarded on this question of rapid and secure communications with Australia. Merchants in London are concerned in it, no less than in the colonies, and if the Imperial Conference is allowed to meet and disperse without a definite course being adopted to remedy the dangers of the situation a very grave responsibility will be attached to every member of it who, having the opportunity, has failed to lift up his voice in earnest protest against the neglect of so vital a matter.

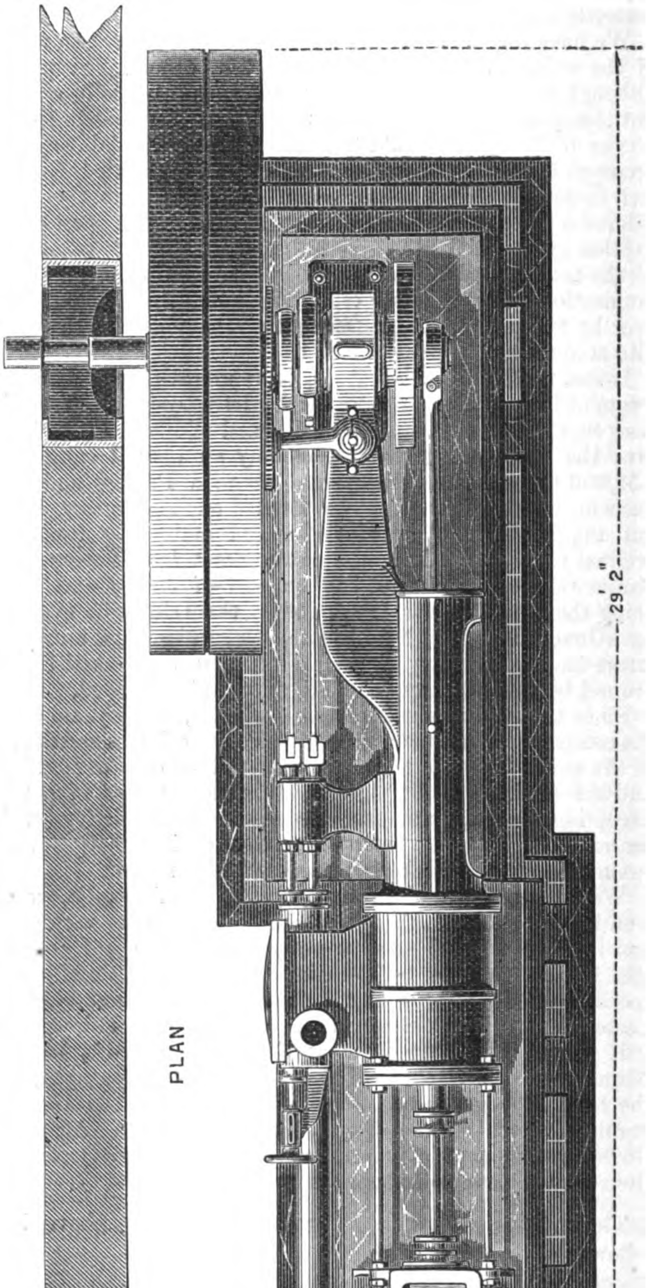
ELECTRIC LIGHT INSTALLATION AT THE HADFIELD MILLS.

This installation, comprising about 1,400 lamps of 16-candle power—probably one of the most extensive yet introduced into a cotton mill—is worked by a horizontal engine and two Edison-Hopkinson dynamos, specially designed and constructed by Messrs. Mather and Platt, of Salford, for the purpose. The engine, illustrated by the accompanying engravings, is high pressure, condensing, with a single cylinder, 23in. diameter, 30in. stroke, intended to run at 100 revolutions per minute, and the work with a boiler pressure of 80lb, and under these conditions will indicate about 170 horse-power.

The cylinder is carried on an independent stand and bolted to the trunk or frame, which is of box section, and supported at the crank end on a separate foot. Both the cylindrical slide and the crank-bearing pedestal are in one piece with the trunk. The piston rod and crank pin are steel, and the connecting rod best hammered scrap. At the crosshead end the connecting rod is forked, and the wear taken up by a wedge and screw; its length is three times the stroke. The crank is of the disc form, and is shrunk and keyed on to the shaft; the crank pin is also shrunk in. The shaft is 8in. diameter, increased up to 8½in. for the fly-wheel, and at the crank end is carried in a bearing 15in. long and at the off end, in an angle pedestal, fixed in a wall box, 12in. long and 6½in. diameter. The main bearing is adjustable both top and bottom and the sides by wedges and screws, so that the brasses can be fixed in any way while the engine is at work. The flywheel is 12ft. diameter and 27in. wide, and is prepared for two 12in. belts. It was cast whole, split and bolted together at the rim, and held with bolts and shrunk hoops at the boss. Its finished weight is 5¼ tons. The main and cut-off valves are worked by two excentrics, having respectively 4½in. and 5½in. traverse. The engine is governed by a Porter governor with steel arms, working on to the throttle valve. All the bearings, the excentrics, crank pins, &c., are lubricated from one oil tank fixed over the main bearing; and the oil is collected by suitable drippers led into a tank below, from which it is returned to the top tank by a pump. The cylinder is lubricated by Mather and Platt's improved sight-feed lubricator, requiring one plug valve only.

The air-pump and condenser are combined. The pump is double-acting, worked by a tail rod from the piston, the cylinder being 10in. diameter, 30in. stroke, and has two suction and two india-rubber delivery clacks of large area at each end. The air pump and cylinder are all bolted to the same stone, and are also tied together by bolts. Throughout, all threads on bolts are fine pitch or gas threads, and in working parts have a nut of ordinary depth locked with a thin one, and in addition have a split cotter through the end of the bolt.

The two dynamos are each capable of an output of 44,000 volt-amperes or watts, equivalent to 750 lamps—110 volts, 400 amperes—at 620 revolutions. They are of the Edison-Hopkinson type, with the length of field-magnets still further reduced, and bar armatures. The commutators are built up of 47 bars of copper insulated with mica, and are readily detachable from the armature. There are three brushes on each rocking arm, each separately adjustable with spring-forward thrust and hold-off catch. The armature bars have a section of 0·106 square inch, and hence the load is three amperes per square millimetre. The dynamos are compound-wound, but owing to the great strength of the magnet field and small disturbance caused by the armature, twelve convolutions of series coils is sufficient to secure perfect compensation for the whole range. The following are the particulars of the resistances:—Armature, 0·00645 ohm; series coils, 0·0013 ohm; shunt coils, 17·4 ohms, showing an electrical efficiency of 96 per cent., and a commercial efficiency of from 94 to 95 per cent.—*Engineer.*



The Electric Light Engines at the Hadfield Mills Installation (Messrs. Mather and Platt, Salford, Engineers).—PLAN.

THE SOCIETY OF CHEMICAL INDUSTRY.—A meeting of the London section of this Society will be held at Burlington House, on Monday, 7th March, at 8 p.m., when a paper will be read by Messrs. Cross and Bevan on "M. Hermite's System of Electrolytic Bleaching."

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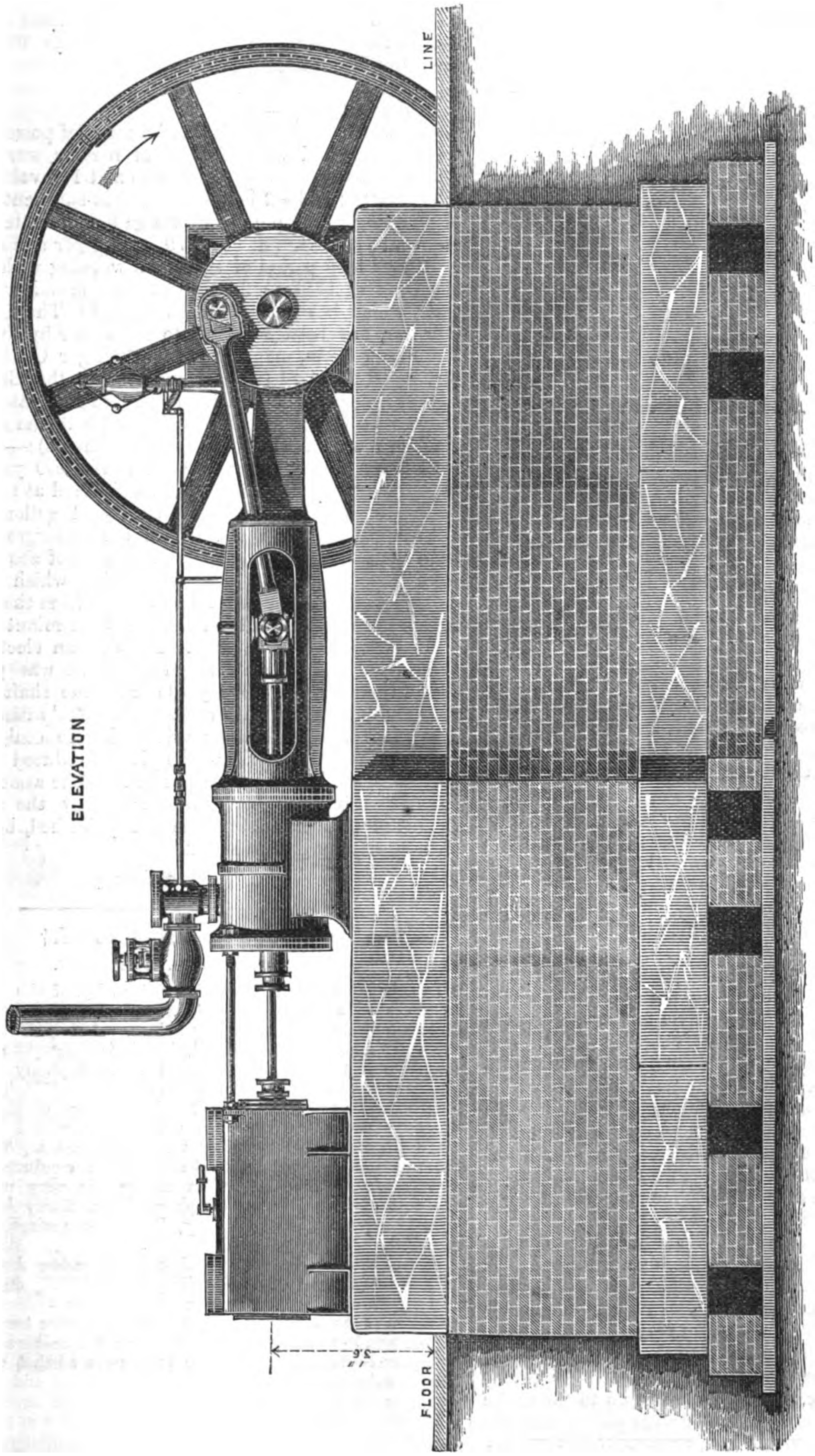
APPLICATIONS OF ELECTRICITY TO MINING OPERATIONS.*

BY F. J. ROWAN, C.E.

There are several advantages inherent to the electrical method of transmitting power which render it very suitable for mining operations, and the writer believes that its employment on a general scale depends mainly upon the existence of greater familiarity with it among those who are engaged in directing or superintending mining operations. It is with the view of contributing to this more intimate acquaintance with electrical methods of working that he has compiled the following information as to the various installations which have been actually carried out, in order to present a short account of them to this institute.



The Electric Light Engines at the Hadfield Mills Installation (Messrs. Mather and Platt, Salford Engineers).—ELEVATION.

A description of the various installations of electric lighting in mines does not come within the design in the following paper, but members may be reminded that this application of electricity has been successfully introduced in the follow-

* Paper read at a recent meeting of the Mining Institute of Scotland.

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ing collieries:—Cannock Chase,* Eppleton Colliery,† at Hetton Hall, Cymmer,‡ and Risca § (S. Wales), Earnock,‖ Low Moor,¶ at Heinrichs-Glück ** Colliery in Peterswald, and at Miesbach and Hausham †† in Bavaria. There are no doubt other collieries similarly equipped on the Continent of Europe and in America, allusion being made to some of these in *Trans.* American Institute M. E., Vols. VI., VIII., and X., &c. The writer's friend, Mr. J. G. Lorrain, is about to carry out the lighting of an extensive mine in Africa on what is a new system in electric lighting in mines, viz., by means of secondary generators or distributors.

The following are the instances of electrical transmission of power in mines which will be quoted:—

(1) *Pumping*, in Trafalgar Collieries, Forest of Dean; and at Thallern Colliery, on the Danube.

(2) *Winding*, Experiments carried out at Trafalgar; at the Thibaut shaft of the Société Anonyme de St. Etienne; at Péronnière Colliery; and at Blanzy mines.

(3) *Haulage*, at Zankerode Pit, near Dresden; and at Beuthen, in Upper Silesia.

(4) *Ventilation*, at Zankerode; at Trafalgar; and at St. Claude, near Blanzy.

(5) In order still further to illustrate the subject, the following applications illustrating generally the transmission of power electrically will be referred to:—

(*a*) The experiments of Marcel Deprez at Creil, Paris, Munich, &c.

(*b*) Pumping carried out at St. Elizabeth and La Sorme.

(*c*) Electrical working in the cannon foundry at Bourges.

(*d*) Application of electricity to mining in New Zealand.

(6) Some data will be given by means of which a comparison between various systems of transmitting power may be instituted.

I. PUMPING.

At Trafalgar Collieries.—This application has been described by Captain Blanch Brain, who says it was started in December, 1882.

"The water to be lifted," writes Captain Brain,‡‡ "drains to a hold in the rocky seam of coal, which is situated about 500 yards distant from the bottom of the shaft and 90ft. vertically below it, midway between two incline engine planes, but in the seam of coal above them. Although the quantity of water is small, the position is out of the way, and difficult to connect with any existing power, as the workings descend over a distance of 1,000 yards beyond, the lowest point of which is 200ft. vertically lower. This made it a matter of importance that the water should not be allowed to follow down."

After going into the cost of working by compressed air and discarding the Warner's horse pumps which had been used, the method adopted was to employ a siphon, the longer leg of which carried the water to the most convenient point for it to run to a pump about 800 yards further down the workings, where the electric motor was fixed. This electric motor was a small one—similar to a Gramme machine—weighing 2cwt. and 40lb., and "capable of giving nearly four horse-power with a suitable current." Captain Brain does not say whether he means electrical or brake horse-power, but the writer supposes he means the former. The pump was double acting, 5in. dia. 8in. stroke, mounted on a cast-iron base, with spur wheel gearing, and a 4ft. pulley for a belt. Two Gramme dynamo machines of size A were provided for generators, but one was found to be sufficient for the work. The electrical cable between the generator and the motor consisted of a strand, ·36in. dia., of 19 wires each ·072in. dia., insulated with india rubber, and sheathed with lead pipe. Its length was 1,000 yards, and its electrical resistance ·313 ohm. The cable was further protected by being laid in creosoted wooden boxes, 3in. by 4in., which were secured to the side of the shaft and to the roof of the travelling road. The total cost of the installation was a little over £250. In addition to the above appliances, an ammeter and a voltmeter were placed near the engineman, and telephones and electric signal bells were fixed in the engine room above and in the pump room underground. These instruments gave all necessary indications of the working of the electrical apparatus, and enabled each stroke of the pump to be heard or signalled so that the actual quantity of water being lifted could be known in the engine room. The engineman could start or stop the motor from the engine room, so that it and the pump could be kept locked up, and opened only for oiling. The engine and generator were fixed on the surface, not far from the top of the shaft, which was 200 yards deep, the pump being nearly 600 yards distant from the generator. A small shunt wire from the cable was connected to two incandescent lamps—one at the pump and one in the engine house, which, consuming a small amount of power, served both for lighting and as indicators of regular working. It was found that a current of 15 amperes and 100 volts potential, or 1,500 watts ÷ 746 = 2 horse-power, was sufficient for the work of pumping. The pump threw a gallon of water per stroke, and could be driven at 60 to 70 strokes per minute.

After a long period of successful working with this plant, it has been decided to fit up electrical machinery on a larger scale, which has not yet been started. The following note, however, has been supplied to the writer by the courtesy of Mr. Frank Brain, manager of the Trafalgar Collieries, through Mr. Radcliffe Ward (who, as engineer to the British Electric Light Company, the owners of the Gramme patents, was associated with Captain Blanch Brain, and lent him some Gramme machines used in his original experiments):—"The present installation for pumping here is about 900 yards from the engine house, where the generator is fixed at the surface; is lifting about 90ft., maximum quantity 34 gallons per minute. We are also driving a 6ft. fan in the underground workings from the same engine house, at a distance of about 1,500 yards from generator. The new installation which we are now putting down will be about 1,900 yards from the generator in engine house, and will lift 100 gallons per minute 300ft."

At *Thallern Colliery, on the Danube** an electro-motor and pump have replaced a steam pump, which was placed at the end of the main road, 900 yards from the shaft, the depth of which is not stated. After several months' satisfactory work, it was found that a considerable saving in coal was effected, and that the temperature of the pit was reduced 14 degrees by the use of the electrical arrangement. The atmosphere of the mine had been rendered unbearable by the steam pump. Details of this installation are not published, but these main facts merely have been stated.

(*To be continued.*)

* B. A. Rep., § G, 1886. † *Trans.* N. of E. Inst. M.E., Vol. 34. ‡ *Ibid.*
§ Rep. of Royal Com. on Acc. in Mines, 1886.
‖ *Trans.* Min. Inst. of Scot., Vol. III., p. 145.
¶ *Jour.* I. & S. Inst., II., '85, p. 553. ** *Ib.*, p. 579. †† *Ib* II., '84, p. 639.
‡‡ *Proc.* S. Wales Inst. of Eng., Vol. XIII., No. 5.

* *Oesterreichische Zeitschrift für Berg. und Huttenwesen*, Vol. 32, p. 182. *Jour.* Iron and Steel Inst., I., 1884, p. 223.

DUPLEX TELEPHONY.†

BY DR. A. M. ROSEBRUGH.

In this paper I desire to call the attention of the members of the Institute to some recent advances that have been made in the direction of duplexing telephone lines. It is now ten years since the telephone was introduced, but it is only quite recently that attention has been directed to duplex telephony. Duplex telephony seems to be adapted to long distance telephony only. In long-distance telephony the best results are obtained when two wires are used, one wire being used as a return wire, the two wires forming what is called a metallic circuit. The wires used for this purpose require to be first-class conductors. They are now made of copper. This necessarily very much increases the cost of long-distance telephone lines, firstly because copper wire is expensive, and secondly, because two wires instead of one are used.

Hence any means or device that will increase the working capacity of telephone trunk lines will proportionately decrease the cost of long-distance communication by telephone.

When I took up this question a little over two years ago my object was to use the metallic circuit or double-wire trunk line system connecting two telephone exchanges so that either two telephone subscribers or a telephone subscriber and a central office operator at each end of the metallic circuit could communicate simultaneously without interference. In order to accomplish this I found that there were two problems to solve, firstly, how to render the central office receiving telephones neutral to the subscribers'

† Read before the Canadian Institute, January 8th, 1887.

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transmitters, and secondly, how to render the subscribers' receivers neutral or irresponsive to the central office transmitters.

The solution of the first problem was not attended with any great difficulty. The plan adopted was as follows, namely: At each central office and at each end of the metallic circuit a subscriber's line was attached. Instead of using the ordinary telephone receiver with a single coil, a telephone with a double coil was used, and instead of inserting said coil in a single branch of the metallic circuit, one coil was inserted in one branch and the other coil in the other branch of the metallic circuit, and the connections were made so that electrical currents traversing one coil would be neutralised by the electrical currents traversing the other coil. Speaking technically, the coils were connected differentially. The electrical currents generated by the subscribers' transmitters passed through the two coils in opposite directions and consequently neutralised each other. Hence while two subscribers, one at each end of the metallic circuit, were using the line nothing would be heard in the central office telephones.

The first problem having been solved I was encouraged to attempt the solution of the second, namely, how to render the subscribers' telephones neutral to the central office transmitters. This was found to be a difficult problem. It was obvious that if the transmitters were placed in either branch of the metallic circuit, the electrical currents generated by said transmitters would divide at the junction of the subscribers' lines, and a portion of said currents would escape to ground through the subscribers' telephones. Without stopping to enumerate the different expedients resorted to I finally saw that the only solution to the problem was to arrange the central office transmitters so that both branches of the metallic circuit would be charged equally, simultaneously, and in opposite directions. By charging one wire positively and the other negatively at the same time, I saw that the electrical equilibrium between the two wires could be disturbed without affecting the equilibrium of the subscribers' lines. Fortunately, after many and various experiments, the means for accomplishing this were discovered and the problem was finally solved.

I also discovered that this can be accomplished in several ways. I will call your attention to but two of these. The first of these methods is to use a transmitter with two induction coils, the primary coils being connected either in series or in multiple arc, and the secondary coils being connected in circuit, the one in one branch of the metallic circuit and the other in the other branch of the metallic circuit. In the second method repeating coils are used with one coil in each branch of the metallic circuit, said coils being connected with each other and also with an independent telephone circuit.

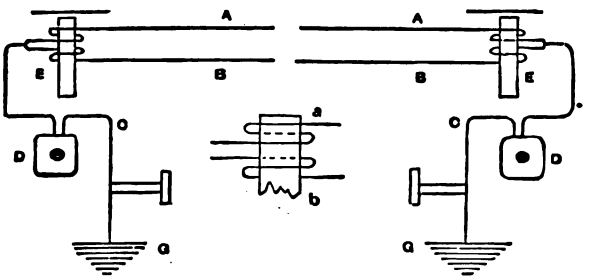

Fig. 1.

In Fig. 1 A A and B B are two branches of a metallic circuit, and C C' are two subscribers' lines attached thereto. D and D', subscribers' transmitters, and E E are receiving telephones at two central offices at each end of the metallic circuit respectively. The telephones E E have two coils, *a* and *b*, the former connected with wire A, and the latter with wire B. These coils are connected differentially, and the telephones are neutral to the subscribers' transmitters.

In the first method the operation is as follows: The voice impulse vibrates the diaphragm of the transmitter; this varies the strength of the local battery circuit traversing the primary coils of the two induction coils; this generates secondary currents in the two secondary coils, and this, in turn, generates electrical currents in the two branches of the metallic circuit, and if the two coils are properly balanced electrical impulses are generated in each branch of the metallic circuit equally and simultaneously, and if the connections are properly made these electrical impulses traverse the metallic circuit in opposite directions, the currents generated in one coil being reinforced by the currents generated in the other coil.* I might mention here in passing that the converse is also true, namely, if the connection of one of the coils be reversed, the currents generated by one coil will be opposed by those of the other, and no current will traverse the metallic circuit; the currents will meet, however, at the subscribers' lines, and, being reinforced, will proceed to "ground" through the subscribers' telephones. Advantage may be taken of this fact, and two sets of transmitters may be used at the central office or at any point in the metallic circuit, and they may be connected in such a manner that the subscribers' telephones will be responsive to one and neutral to the other.

* Adjustable cores are used in connection with the two induction coils for the purpose of balancing, in case the two branches of the metallic circuit are not perfectly balanced.

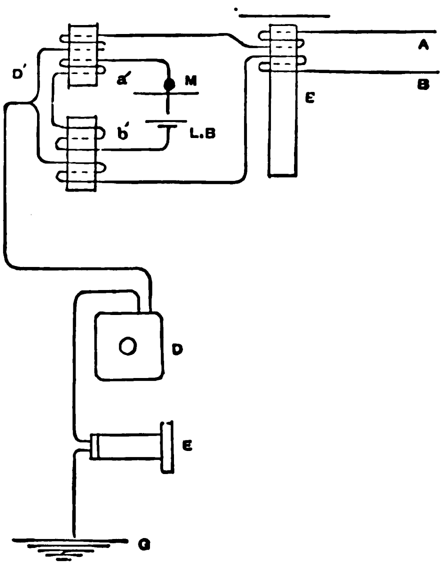

Fig. 2.

In Fig. 2 A and B are the two branches of a metallic circuit at one end of a telephone trunk line. C is a subscriber's line, and E a receiving telephone in said subscriber's line. D' is a transmitter with two induction coils at the central office. The secondary coil of coil *a'* is in circuit with wire A, and the secondary coil of coil *b'* is in circuit with wire B. M. is a microphone, and L B the local battery connected with the primary coils of *a'* and *b'*. E is the differentially wound receiving telephone at the central office.

Preferably, however, I would give the subscriber both a return wire and a ground wire, and, preferably, two installations of telephonic apparatus; one a single installation for ordinary use, and the other an installation of duplex apparatus for long-distance telephoning on the metallic circuit.

When repeating coils are used for charging the two branches of the metallic circuit said branches are charged indirectly through said repeaters. I am aware that there is nothing new in using repeating coils in telephone circuits, but, so far as I am aware, they have never been used as here described, nor with the same object in view, namely, to actuate and to be actuated by both branches of a metallic circuit simultaneously. The advantage of using repeaters, as here indicated, is to enable two subscribers at each end of the metallic circuit to communicate simultaneously without interference, one subscriber using a line connecting directly with the metallic circuit, and the other subscriber using a line connecting indirectly by means of the two repeating coils. Hence, by a combination of these two methods it will be seen that either two subscribers or one subscriber and a central office operator at each end of a metallic circuit may communicate simultaneously without interference.

One important advantage resulting from this arrangement remains to be mentioned, namely, the subscribers have the advantage of two conductors instead of one. This reduces the resistances of the line one-half, and must necessarily very much improve the working of long-distance telephone lines. This idea may be extended as follows:—Two metallic circuits may be connected at each end so as to form a third metallic circuit. This third metallic circuit may contain duplex central office telephonic apparatus and form a connection with a subscriber's line as well. This would give the subscriber the benefit of four conductors. The four trunk lines would be formed into three metallic circuits, and three repeating circuits could be used. In other words, the four wires would admit of four subscribers at each end of the line using the same wires simultaneously.

In August, 1885, I communicated my duplex telephone system to Prof. S. P. Thompson, of the Finsbury Technical Institute, London, and, through his advice and kind offices, a patent was taken out in Great Britain. An application was also filed at Washington. I submitted my system to the American Bell Telephone Company in May last, but I have not learned whether it has as yet been put in practical operation. In the meantime two claimants have made their appearance, namely, one J. J. Curry and one J. A. Barrett, the former an *employé* of the New England Telephone Company, and the latter an *employé* of the New York Telegraph and Telephone Company, both under the control of the

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Bell Company, One claims the arrangement of the differentially wound apparatus, and the other the arrangement of the repeating coils.

I will conclude this paper by giving two extracts from the New York *Electrical World* bearing upon the subject. The first appeared July 31st, or about two months after my system was submitted to the Bell Telephone Company. It says :—"The great expense attending the construction of copper lines for long-distance telephony has naturally led those engaged in solving the long-distance problems to seek means for increasing the capacity of the wires. The steps to be taken are analogous to those adopted in the case of the telegraph, where the duplex and quadruplex have greatly increased the value of the lines. It is not hard to believe the report, therefore, that the American Telephone and Telegraph Company, a description of whose lines between New York and Philadelphia we gave lately, is now undertaking experiments with the object of duplexing its wires, and thus practically doubling their capacity and utility. Several methods of duplexing telephone lines have already been proposed and have been the subject of discussion and trial among telephonists, but they have not come into use, in this country at least. The delay has been due probably to a lack of necessary incentive, such as the long-distance service now furnishes. While the difficulties to be overcome in the duplexing of telephone lines are greater than with the telegraph, it is safe to say that satisfactory results will in time be attained. We understand that the work in the present instance is in highly competent hands, and even now gives excellent promise of developments scarcely hoped for."

The second notice appeared October 23rd last, and reads as follows : — "The telephone lines connecting New York and Philadelphia, recently erected by the American Telephone and Telegraph Company, of this city, have already been described in our columns. It was evident to all interested that lines running parallel for over one hundred miles would suffer from induction if the ordinary 'grounds' were employed ; hence complete metallic circuits of hard-drawn copper wire were erected, through which the articulation obtained, as we have ourselves tested, leaves nothing to be desired. It becomes manifest, however, that the erection of a double circuit is accompanied by a considerable increase in the cost of construction. Hence it is but natural for the company to seek in some way to increase the capacity of its lines, but still to retain the advantages of the metallic circuit. The duplexing of these telephonic circuits was therefore undertaken by Mr. John A. Barrett, of Brooklyn, who has succeeded in devising a system which, broadly stated, *consists in bringing the metallic or double-wire instruments at the terminal stations into inductive relation, by means of converting or repeating coils, with both sides of the circuit.*"

The question of priority of invention will be decided by the United States Patent Office, and I doubt not due justice will be done in the premises.

THE SOCIETY OF TELEGRAPH - ENGINEERS AND ELECTRICIANS.

At an ordinary meeting of this Society, held at the Institute of Civil Engineers, Great George-street, Westminster, on Thursday, 23rd ult., the President, Sir Charles Bright, in the chair, the discussion on the paper by Prof. Silvanus Thompson on "Some Telephonic Investigations" was resumed.

Prof. Forbes remarked that although Prof. Thompson had drawn up a long list of the varieties of transmitters, it had always seemed to him that for practical purposes these instruments might be divided into only two distinct classes. (1) Those which were really Hughes microphones, and always worked admirably ; (2) all other sorts with or without legal diaphragms, and which always worked vilely. He had recently been making some experiments with an instrument of the latter class upon a principle which did not, however, appear to be included in Prof. Thompson's catalogue. It had occurred to him that a platinum wire, maintained at a red heat by a local current ought, when spoken to, to act as a transmitter ; the experiment proved perfectly successful, although, of course, the instrument possessed a purely scientific interest. The action was due to the variation of the temperature, and therefore of the resistance, of the wire, as the waves of air impinged upon it. Various forms had been tried, and it was found that a wire drawn down by the Wollaston process to a diameter of $\frac{1}{1000}$ inch gave the best effect—the longer the wire and the higher the temperature to which it was raised the better. Prof. Forbes then referred to the question of the necessity of initial magnetisation in the core of the receiver, and pointed out that since the attraction upon the diaphragm varied as the square of the magnetisation we should naturally expect to obtain a greater variation in the attraction by an increase in the initial magnetisation.

Colonel Webber asked for some information with regard to the "membrane" receivers, some of which he had seen in operation with marked success ; and he had wondered how the difficulty of preserving the membrane from the effects of moisture had been overcome. In discussing the problem of long-distance telephony, he thought that Mr. Preece had not sufficiently distinguished between the intermittent currents of telegraphy and the underlatory currents of the telephone. With currents which are required to be intermittent at the receiving end, the static capacity of the line must not exceed a certain maximum if a certain rate of working is to be maintained. Otherwise there will not be time for "discharge" between successive signals, and the line becomes "blocked." The case is different where the currents are undulatory. A telegraph instrument has to perform the mechanical analysis of the consecutive currents received, whereas the telephone performs an analysis of the condition of magnetisation of the core. There was, however, one species of telegraph which discharged a function much more like the telephone itself ; this was Elisha Gray's harmonic telegraph. He had always thought that Elisha Gray had not received all the honour which was justly his due. At the Paris International Exhibition of 1876 he (Colonel Webber) was a member of the committee which had to report as to the award of the Grand Prize, and that committee was unanimously of opinion that the claims of Gray and Bell were of equal merit. The fact was that Gray, searching for a telephone, discovered the harmonic telegraph, while Bell, searching for an harmonic telegraph, discovered the telephone.

Prof. Ayrton said that the explanation given by Prof. Forbes as to the necessity for initial magnetisation in the receiver was undoubtedly the true one ; a similar explanation had recently been given by Oliver Heaviside in *The Electrician*. He thought that Prof. Thompson, carried away by his intense admiration for electrical phenomena, was perhaps inclined to make too much of the difficulty of accounting for microphonic action. He himself thought that the theory that a succession of small arcs were formed between the carbons had yet to be disproved. The resistance of an arc varies we know with the current ; the resistance of a microphonic contact had been shown to vary in the same way. He should like some day to make an experiment in order to determine whether it was possible to start an arc between two carbons by heating the space between them. The experiment would, he thought, succeed in rarefied air. He quite agreed with Prof. Thompson as to the importance of a suitable construction of the induction coil. There was a certain amount of vagueness in people's ideas as to whether a closed magnetic circuit should or should not be used for an induction coil. It had, however, been shown by the Comte du Moncel that this depended upon whether you were going to work with reversals or merely with intermittent currents. In the former case the closed core is better, in the latter case it is preferable to use an open core. For overhead wires the values of the coefficients of self and mutual induction are, as a rule, of infinitely greater importance than the amount of static induction ; and it was impossible to determine whether or not a telephone could work over a given line from a knowledge merely of its resistance and capacity. Mr. Preece was also wrong in his conclusion that if we could not alter the speed of signalling on a given line, it was therefore useless to trouble ourselves about the instruments at the two ends. Sir William Thomson, under similar circumstances, came to the very opposite conclusion. As for the claims of Bell, it was he who first demonstrated by what simple means it was possible to transmit speech. But do we employ his transmitter? No, we do not. If we did, the telephone in London to-day would be in an even more deplorable condition, if that be possible, than it actually is.

Mr. H. G. Yateman expressed the opinion that the action of the telephone should be ascribed to "sonorous electric discharges," and gave an account of some interesting experiments, in which the human body was made to play the part of a condenser plate, and sounds were rendered audible when the hand was placed over the ear of a second individual.

Dr. Fleming agreed with Prof. Ayrton that the problem dealt with by Mr. Preece was not really that of the transmission of articulate speech, because the self-induction had been left out. The resultant or virtual resistance of the line, when self-induction has been taken into account, is really the important quantity. It was only possible to construct a coil which should give its maximum inductive effect for one particular period ; therefore, the coil should be constructed with reference to that particular period of vibration which is most prominent in the human voice. The self-induction of the secondary coil should be as small as possible. For this purpose the diameter of the coil should be large, and the magnetic circuit should be open, not closed.

The President then called upon Prof. Silvanus Thompson for his reply.

Prof. Thompson said that he found himself in a somewhat fortunate position, the various speakers having already answered one another's criticisms, and leaving him with scant room for further reply. Taking the speakers, however, in reverse order, he would observe that Dr. Fleming laid no greater

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stress upon the importance of a proper construction of the induction coil than he did himself; in fact, he had bestowed a good deal of labour upon the design of a coil which should have a maximum coefficient of mutual induction, together with minimum self-induction in the secondary circuit. This was not altogether an easy thing to secure, especially when it was also necessary that the coil should be capable of cheap construction. With regard to the winding of the coil of the receiver, it might be mentioned that the arrangement always adopted in practice, in which the coil was placed upon one end only of the magnet, gave a smaller coefficient of self-induction, and was therefore on this account preferable to the arrangement of winding the coil over the whole length of the magnet. This fact had been pointed out by Prof. Bell himself. He agreed very largely with Mr. Yateman's remarks as to the class of telephones which were operated by static inductive action. He had felt no surprise at hearing Prof. Ayrton propound what was known as the "heat theory" of microphonic action; but for his own part he could not see that it tended to any real advancement of our knowledge to say that the microphone is an arc. It was, in fact, less easy to study what was actually going on in the arc than in the microphone. So that he should rather prefer to regard the arc as a big microphone contact. Some light might possibly be thrown upon this question by comparing the phenomena of the arc with what we know takes place in the spheroidal state, where the molecules are in a state of rapid vibration between the heated surface and the lower layer of the liquid. With regard to the question of open *versus* closed magnetic circuits it was worth noting that so long as twenty-five years ago Prof. Trowbridge had described in *Silliman's Journal* some experiments bearing upon this very question. No one felt a more profound admiration for the beautiful researches of Mr. Stroh than he (Prof. Thompson) did. He was looking forward to finding an opportunity of repeating the experiment, and seeing for himself the wonderful gyrations of the particles contained in the little drop of oil. He was also much interested in the experiments described for the first time by Prof. Forbes, and agreed with him in his explanation of the function of the initial magnetisation *up to a certain point*. But it certainly did not account for the whole of the observed phenomena. He would describe an experiment which he had made in which the variation of magnetisation and not the variation of attraction was measured, and in which, therefore, the influence of the *square* of the sum of the initial and temporary magnetisation did not intervene. He had taken a bar of soft iron wound with three independent coils. In the circuit of one of these he had placed a telephone. In the circuit of the second he placed a microphone, connected with a watch as a source of sound. Around the third coil he sent a current which could be varied at will so as to increase or decrease the magnetisation of the core. It was then found that the loudness of the sound in the telephone continuously increased as the magnetisation of the core was increased, even when this was pushed up very near the saturation point. The result was quite unexpected, and he should look forward with much interest to any explanation; for himself, he was unable at present to suggest one. The remainder of Prof. Thompson's speech was devoted to a detailed reply to the criticisms of Mr. Preece, which he proceeded to answer point by point. The observations were at times somewhat of a personal character, and succeeded in creating a good deal of amusement among the members present.

PHYSICAL SOCIETY.—Feb. 12.

Prof. B. Stewart, F.R.S., President, in the chair.

In opening the proceedings of the general annual meeting of this society the President, Prof. B. Stewart, F.R.S., regretted that in their report the council have to record the loss of one who took a prominent part in the proceedings of the society, the late Dr. Guthrie. It was, however, satisfactory to learn that the appeal of the Guthrie Memorial Committee, under the presidency of Prof. Huxley, had been generously responded to. The council also learn with regret from Dr. E. Atkinson that owing to pressure of work he is unable to retain the office of treasurer to the society, and desire to express their thanks to him for his past services. Prof. Rücker has consented to be nominated for the office thus rendered vacant, and the council believe that by his election the connection between the society and the normal school of science (which is so desirable) will be maintained.

The report of the council for the year 1886 was read and received, and the following gentlemen were elected members of the council for the present year:—President: Dr. Balfour Stewart, LL.D., F.R.S. Vice-presidents: Dr. E. Atkinson. Prof. W. E. Ayrton, F.R.S.; Shelford Bidwell, M.A., LL.B., F.R.S.; Prof. H. McLeod, F.R.S. Secretaries: Prof. A. W. Reinold, M.A., F.R.S., Walter Baily, M.A. Treasurer: Prof. A. W. Rücker, M.A., F.R.S. Demonstrator: C. V. Boys, M.A. Other Members of Council: R. H. M. Bosanquet, M.A.; W. H. Coffin, Conrad W. Cooke, Prof. G. Forbes, F.R.S.E.; Prof. T. Fuller, M.A.; Prof. J. Perry, F.R.S.; W. N. Shaw, M.A.; Prof. S. P. Thompson, D.Sc.; M. Whipple, B.Sc.; C. R. Alder Wright, D.Sc., F.R.S.

The President proposed the following resolution:—That at the end of clause 11 of the bye-laws, which says, "Every candidate for admission into the society shall be recommended by not less than three members, to two of which he must be personally known," there be added, "when a candidate living abroad is a member of a recognised scientific society, such membership may, subject to the approval of the council, be held equivalent to the personal knowledge aforesaid." The resolution was carried, subject to confirmation by a special general meeting to be held on Feb. 26. A vote of thanks, proposed by Prof. Ayrton and seconded by Prof. M'Leod, to the Lords of the Committee of Council on Education, for the use of the rooms and apparatus of the Normal School of Science, was passed unanimously. The Hon. R. Abercromby proposed a vote of thanks to the officers of the past year for their gratuitous services, which was seconded by Prof. Pickering. Sir Phillip Magnus proposed a vote of thanks to the auditors, Colonel Festing and Prof. Fuller, which was seconded by Mr. Lecky, and passed unanimously. Mr. J. Brown was elected a member of the society. The following communication was then read:—

Note on the Tenacity of Spun Glass, by E. Gibson and R. E. Gregory. The authors have experimented on the tenacity of glass rods and fibres made from the same piece of glass. The fibres varied from $\frac{1}{15}$ to $\frac{1}{50}$mm. and the rods from about $\frac{1}{2}$ to 1mm. in diameter. They find the tenacity per sq. cm. of rods increases as the diameter decreases, as in ordinary wires, whereas with fibres this is not shown. Experiments were shown illustrating the method of working, and the highest tenacity recorded was for a fibre of ·0340mm. diameter, which gave 466 × 107 dynes per square cm., a value about half as great as that for steel wires. The authors refer to Quincke's suggestion that the increased tenacity of small wires is due to surface tension, and may be represented by $W = Ad + Bd^2$, where W is the breaking weight and d the diameter, but their own results with glass do not agree with the formula. Sir Philip Magnus asked if the diameters were measured at the point of rupture, if the elongation was determined, and whether the authors were able to suggest any other formula which would express their results. Mr. C. V. Boys remarked that the tenacity being so much affected by accidental circumstances, such as rate of cooling, no such formula could be expected. Prof. Rücker, referring to Quincke's experiments, said that the surface tension of metals calculated from them appears impossible. After some further remarks by the president, Prof. Ayrton, Mr. C. V. Boys, Prof. McLeod, and Mr. Gregory, the proceedings terminated.

Feb. 26., Special General Meeting, Prof. W. A. Adams, Vice-President in the Chair.

The resolution passed at the meeting on February 12th, providing greater facilities to persons living abroad for qualifying for membership of the society, was unanimously confirmed. The meeting was then resolved into an ordinary one, at which Prof. W. Stroud and Mr. G. S. Gulbenkian were elected members of the Society.

Mr. James Swinburne read a *Note on Prof. Carey Foster's Method of Measuring the Mutual Induction of two Coils*. The author described an apparatus devised last summer for measuring mutual induction by a null method, thus dispensing with a ballistic galvanometer. The induction in the secondary coil is balanced by an opposite effect produced by a variable known fraction of the primary current passing through one wire of a double wound coil of known mutual induction, the other wire of which is joined in series with the secondary coil and galvanometer. In a preliminary trial, using an ordinary reflecting galvanometer, it was found that instead of no deflection being observed, two kicks in opposite directions occurred when there was iron in the circuit. A new galvanometer with heavy needle is now being constructed to overcome this difficulty. A null method of finding the ohm by means of a differentially wound heavy needle galvanometer is suggested in the latter part of the note. Prof. Ayrton pointed out that Prof. Foster's method does not require readings on a ballistic galvanometer, and mentioned that in practice it is greatly superior to those given in Maxwell and the ordinary text-books. The chief drawback is the necessity of having large condensers of accurately known capacity where large coefficients are concerned. A large number of experiments have been carried out at the Central Institution by Mr. Sumpner with very satisfactory results. Prof. Adams concurred in Prof. Ayrton's statement regarding the difficulties in using Maxwell's methods in practice, and expressed his satisfaction with the great simplicity of Prof. Foster's method.

On the Determination of Coefficients of Mutual Induction by Means of the Ballistic Galvanometer and Earth Inductor, by R. H. M. Bosanquet, M.A. The methods described depend on two measurements of the throws of a ballistic galvanometer; first, that produced by the sudden rotation of a coil (the constants of which are accurately known) through 180° about a vertical axis; and, second, that produced by the mutual induction to be measured, when a current of known strength is started in the primary circuit. The earth induction coil is permanently joined in series with the ballistic galvanometer and secondary coil, and the primary current measured by an absolute tangent galvanometer of the Helmholtz pattern. If Q_0 and Q be the quantities of electricity which pass through the ballistic galvanometer in the two experiments, then $Q_0 = \frac{2NAH}{R}$, where NA is the effective area of the inductor, and $Q = \frac{MC}{R}$, where $C = GH\tan\theta$. Hence $\frac{Q}{Q_0} = \frac{MG\tan\theta}{2NA} = \frac{\alpha}{\beta}$, where α and β are the throws of the ballistic galvameter. From the above we get

$$M = \frac{\alpha}{\beta}\,\frac{2NA}{G\tan\theta}.$$

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A modification to be used when M or R are very large is also described. Numerical results obtained are given, from which it is inferred that Maxwell's formulæ for calculating the mutual induction of two circular coils cannot be applied where the distance between their central planes is at all comparable with their radii. Experiments on an A Gramme dynamo gave very irregular results when the currents were small, owing to the sub permanent magnetism of the machine. Further uses of the method are suggested, such as the absolute determination of capacity and resistance. Remarks on the subject were made by Prof. CAREY FOSTER and Mr. SWINBURNE; and Prof. AYRTON replied to Mr. Swinburne's contention that Prof. Foster's method was not independent of observations of a ballistic galvanometer (since capacities are determined by theirmeans), by pointing out that where accurate standards exist it is quite legitimate to base other absolute measurements on them.

Prof. REINOLD then read an abstract of a paper on *The Continuous Transition from the Liquid to the Gaseous State of Matter at all Temperatures*, by Prof. W. RAMSAY and Dr. SYDNEY YOUNG. The authors find the relation between pressure and temperature of gases and liquids at constant volume expressible by $p = b\,t - a$, where b and a are constants, and therefore conclude that the *isochors* (*i.e.*, curves connecting p and t for constant volume) are straight lines. At temperatures below the critical point the isotherm during passage from the gaseous to the liquid state is a serpentine curve intersected by the horizontal line of vapour pressure corresponding with that temperature, the two areas between the curve and straight line being equal. By experiment and extrapolation the authors find the loci of the apices of the serpentine curves, corresponding with different temperatures, to intersect at the critical point. The above results are proved for ether and carbonic dioxide, and the authors believe them to be true for all stable substances. Prof. Rücker remarked that if similar relations hold for liquids and solids, the triple point of intersections would be of immense interest. Prof. Perry, whilst regarding the results as of vast importance, thought the curves and calculations should be very carefully discussed before being finally accepted.

ELECTRIC LIGHTING ACT AMENDMENT BILL.

In the House of Lords on Wednesday last Lord THURLOW said that in asking their lordships to give a second reading to this Bill he desired to say that its subject was not newtohim, as he had for the last five years been practicallyand commercially connected with the industry, and for four years had been one of the fewmembers of theirlordships' House who had had electric light in his own house, and thus had daily opportunity of studying it and of appreciating its comfort and convenience. It would be interesting to know how many of their lordships actually had introduced electric lighting into their houses. He should think a dozen or a score would be the outside. Among them, however, there was, he was glad to say, the leader of the House, the noble marquis the head of the Government, who had the honour of having been one of the earliest and most successful pioneers of electricity, not only in connection with lighting, but with the transmission of power. He could not help thinking that the experience of the noble marquis would make him concur with him in thinking that the moment had now come to amend the Act of 1882, under which, as it stood, central lighting stations and house-to-house lighting were a commercial impossibility. Their lordships must remember the circumstances under which that Act was passed. The science was then in its infancy. Not long before Lane-Fox and Edison had made discoveries in filaments and attachments that had for the first time made incandescent lighting practically possible. Electric lighting then rapidly became a medium for the heaviest gambling in shares known since the South Sea Bubble. So great was the notoriety of this gambling that the Government of the day felt bound to step in to prescribe rules for regulating and arresting the flow of capital into all kinds of hasty and ill-considered schemes. All this had now completely changed. The gambling spirit that raised £5 shares to £60 had passed away and been buried in the ruins of many of the companies which were then promoted, and the stage of leisurely repentance had been reached. Meanwhile immense progress had been made in every branch of electric lighting. Of course, much work remained to be done. Reliable and simple meters were still required, but the position had quite changed. Electric lighting was no longer a dream of the future but a reality, and commercially possible but for the Act of 1882. For example, ship lighting, subjected to no trammels, was now being universally adopted by all the great companies, the Cunard, the P. and O., the German Lloyd, and by the navies of the world. Even great buildings, large enough to make them independent of central lighting stations, and able to generate electricity for themselves, had adopted it, such as Buckingham Palace, the Grand Hotel, the Métropole and First Avenue Hotels, several theatres, the Athenæum Club, the Junior United Service Club, the Junior Carlton, South Kensington Museum, the British Museum, the Grosvenor Gallery, and many more; but house-to-house lighting remained an utter impossibility, as capital could not be raised under the onerous provisions of the Act of 1882 for central lighting stations. Let their lordships compare with this state of things the position of the science abroad and in America, where it was estimated that upwards of £32,000,000, of which £21,000,000 were in arc and £11,000,000 in incandescent, had been invested in electric lighting. To come, however, to the Bill before the House, their lordships would remember what passed on the subject last year, when three Bills were introduced. For Bill No. 1 he was himself to a large extent responsible, as it was the Bill of a committee of experts and scientific men who had considered the matter for two years, and over which he had the honour to preside. That Bill aimed, no doubt, at too much. Its object was to put electricity on the same footing as gas. This was considered as a desire to set up a second monopoly, while the real object was only to enable it to compete successfully against an existing monopoly. Bill No. 2 was brought in by a noble viscount not now in his place (Lord Bury), whose knowledge of the subject was accurate and extensive; and Bill No. 3 was the Government Bill. Those three Bills went to a Select Committee, and important evidence was heard, among others that of Sir F. Bramwell, Mr. Preece, Mr. Forbes, Mr. Hucks Gibbs, Mr. Cohen, and Mr. Crompton. The result was the amendment of the Government measure, Bill No. 3, and in that amended shape it would have passed into law had it not been for the change of Government and death of the Parliament. The present Bill was founded on that Bill with only one addition. It was last year's Bill No. 3, as amended in committee with "goodwill" added. It only amended the Act of 1882 as regarded clause 27, which dealt with the compulsory purchase of an undertaking by a local authority. The clause as it stood had been irreverently called the "old iron clause," because under it property was to be compulsorily bought at its break-up value, irrespective of its value as a going concern, after only twenty-one years. The effect of that was to compel undertakers to charge such a rate for electricity as was practically prohibitive, and prevented its competition with gas. On this point he must confess to holding strong views, and he could not see why this industry should be treated differently from any other in the event of compulsory purchase by a local authority. Indeed, it had some claims to almost preferential treatment on account of salubrity, cleanliness, and safety. It seemed to be only a question of an alternative—either to allow a fair valuation of goodwill of the business, or to grant the licence for such a prolonged period as would enable undertakers to recoup themselves without charging a prohibitive price. If fifty years were granted this might meet the case, but on the whole it seemed wiser to shorten the preferential term, and to provide for competition at its expiry. This was the only question really to be settled. All were agreed on other points, such as the lamp clause, continuous supply, &c. The goodwill question was a thorny one, and admitted of much being said on both sides. His desire was to place it before the House as an open subject for the House in its wisdom to decide. He was willing to accept any reasonable amendments in Committee if the House would permit the Bill to be read a second time, and he was willing to postpone the Committee stage to any reasonable date to suit the convenience of the Government and to afford time for deliberation. His only desire was that legislation should proceed this Session, and that an industry which only required fair conditions to progress should, in these days of depression and of large armies of unemployed, go on for the good of trade and of mankind at large. His object was to come to the relief of an industry capable of rendering the most important services to civilisation. His own belief was that before many years they would find the Board of Trade prescribing electric lighting on the score of health and safety in all factories, schools, mines, theatres, churches, and the like; that the gas companies in England would follow the example of the gas companies on the Continent and in America—convert their plant and become purveyors of electricity; and that finally registrar-generals of the future would be able to trace to this cause increased immunity from consumption and other kindred diseases which infalliby arose to a great extent from vitiation of the atmosphere now breathed. He could only say, in conclusion, that if the Government would undertake to deal with the matter he would gladly leave it in their hands, and that he was willing to consider all points open to fair consideration in committee if their lordships would accept the view he took of the desirability of speedy legislation and allow the Bill to be now read a second time.

Lord HOUGHTON, while not desiring to oppose the Bill, pointed out that it differed from the measure of last year in one additional important particular which had not been mentioned—namely, in regard to the powers of the local authority. What the local authorities asked for under the Bill was nothing less than an absolute power of veto upon any lighting undertaking being started in their district. He thought that where a local authority was dissatisfied with or objected to an electric lighting undertaking, the matter might be referred to the Board of Trade, and if there were any grounds for refusing the application, that a special report should be made to Parliament. He hoped his noble friend would consider that suggestion.

The Earl of CRAWFORD and BALCARRES strongly supported the second reading, and held that compulsory purchase without consideration for the goodwill of a successful undertaking would be unreasonable. He argued that there should be some *quid pro quo* for the permission given to companies to carry out their works, but it should be an equitable one. Personally, he would prefer that some means should be introduced into the Bill whereby the companies could pay a fair and proper rent to the local authorities.

Lord BRAMWELL said he was a member of the Committee which sat upon this question, and there was one thing certain, that legislation upon this subject was necessary. Electric lighting was now a success, and it might be relied upon—whether it beat gas or not was another matter—that, at all events as a private luxury, it was a success. It could not be supplied to the public because of the law as it now stood. The law was certainly a very hard one indeed. It was that at the end of a definite period a concern, however successful, might be bought up by the local authority upon terms which provided for no compensation to those who had risked their capital in what might not have proved successful. Under these terms the capitalists would not subscribe, and it was in vain to tell them that they ought. They would not. And the consequence was there was no public electric lighting. The local authorities did not undertake the electric lighting themselves, but after a company had successfully done so, then they wanted to buy the undertaking at par. He trusted their lordships would take a more reasonable view of the matter, and say that the proposition of the noble lord (Thurlow) was a reasonable one.

The MARQUIS OF SALISBURY said that after the speech of the noble and

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learned lord (Bramwell) he had really very little to say, because he thought the noble and learned lord had represented the case with absolute fairness. He, perhaps, might be allowed to clear himself of the charge which the noble lord on the front Opposition bench seemed inclined to level against those who supported the Bill. He had never been bold enough to have a single share in any of these electric lighting companies. He looked at the matter virtually as a public question, and he had no interest in it except as a means of promoting a product of public utility. Now, the history of this case was really the history of the action of a public Department. The Board of Trade was horrified, and intelligibly horrified, at the position in which Parliament found itself in respect to water companies. It was not entirely satisfied with the position in which Parliament found itself with regard to gas companies. He did not say that that feeling had so much plausibility as the other. But the Board seemed to have resolved that it would not allow Parliament, as representing the public, to fall into the difficulty again, and that it would take good care, when electricity came for its authorisation to Parliament, that terms should be arranged which would place the public in a much better position than they were with regard to gas and water companies. But this very natural and praiseworthy feeling had been carried to an exaggerated point. Their precautions were excessive. The legislation which was passed in 1882 had absolutely stifled the enterprise of those who wished to introduce the electric light into this country. They were now in this position. While in other countries the electric light was used for public purposes, it really could not be used in this country except by those companies, or institutions, or persons who might have the whole machinery for their own use, and produce their electricity entirely for themselves. He could not imagine that Parliament could look upon this as a desirable state of things. Why were we not to have the comfort and advantage of this light, which those who were in a position to use it showed every day an increasing desire to have? The only argument that had any plausibility—and it was an argument which appeared to prevail in the minds of many noble lords—was that they would save the rights of local authorities in this matter. He did not dispute that this was a very suitable matter for local authorities to undertake if they were willing to do so, and he could quite imagine that in 1882 the Board of Trade and the local authorities generally speaking thought it would be a pity to allow companies to step into their place. But five years had passed away, and they saw that the local authorities were not generally inclined to take this enterprise up. They were really putting the local authorities in the position of the dog in the manger — they would not allow companies to enter upon an enterprise which they would not undertake themselves. He was inclined, in spite of the terror of the example of the gas and water companies, to go back to ideas of less restriction and greater freedom in this matter, to allow enterprise to have its full swing, to remove all obstacles which had hitherto impeded it, and to offer terms, not such as they thought the capitalist ought to accept, but which they felt by experience he would accept. So it might be possible, by giving rights which were generous and large, to procure for the public the full advantage of those scientific inventions which other nations had, and which now, by a restrictive policy, we prevented ourselves enjoying, without doing any good to those local authorities which were the subject of such tender care.

The Bill was read a second time.

COMPANIES' MEETINGS & REPORTS.

The Telephone Company of Egypt (Limited).

The fourth ordinary annual general meeting of this Company was held on Tuesday last at the offices, 14, Austin-friars, E.C., under the presidency of Lieut.-General A. Fraser, C.B., R.E.

The SECRETARY (Mr. Alexander B. Chalmers) having read the notice convening the meeting,

"The report of the Directors stated that the Profit and Loss account, including £192. 5s. 8d. brought forward from last year (after providing for income-tax, and writing off a sum of £233. 12s. 10d., for depreciation) exhibits a balance at credit of £4,063. 14s. 2d., out of which your Directors recommend the payment of a dividend of 6 per cent. on the preferred shares, carrying forward £442. 8s. 2d. As referred to in last report, an extraordinary general meeting of the shareholders was called on the 25th May, to alter several of the Articles of Association of the Company, amongst others, Article No. 82, to omit therefrom the word "cumulative," to take effect from 1st January, 1886. This article originally provided for the payment of a "cumulative" preferential dividend of 7½ per cent. per annum on the preferred shares. The proposed alteration having been duly passed and confirmed, future dividends will be applied specially to the years for which the accounts are issued so soon as the arrears previous to the 1st January, 1886, have been discharged. The said arrears have arisen through the income of the Company in past years having failed to pay the full cumulative dividend. These arrears were 4½ per cent. for the year 1884, and 7½ per cent. for the year 1885."

The CHAIRMAN moved the adoption of the report and accounts, observing that the business of the Company showed a steady increase. The number of subscribers in Egypt had advanced from 454 in 1883 to 817 in 1886, while the gross revenue had grown from £6,400 to £9,400 in the same period. It could hardly be expected that any great extension of business would take place in Egypt, but from their knowledge of what was going on there, the Directors were quite satisfied that they had not yet reached its limit, and that they would have further progress to report in future. The dividend they proposed to pay this year was 6 per cent. on the preferred shares, carrying forward £442.

Mr. THOMAS LLOYD seconded the motion, which was carried unanimously.

The CHAIRMAN next proposed the re-election of the retiring Director, Mr. Thos. Lloyd.

The motion having been seconded by Mr. G. B. FROST, who warmly eulogised Mr. Lloyd's services to the Company, was agreed to *nem. con.*, Mr. LLOYD afterwards suitably acknowledging the compliment.

Messrs. Price, Waterhouse and Co., the auditors, were also re-appointed, on the motion of Mr. M'LEOD, seconded by Mr. HENSCH.

Mr. FROST then proposed a vote of thanks to the Chairman, remarking that in these times of commercial depression it was something for a company to be able to pay 6 per cent. on its capital of £60,000. It showed that the Oriental Telephone Company, which held a large proportion of the shares in this Company, had not only a substantial but remunerative investment.

The CHAIRMAN briefly replied, and bore testimony to the tact and ability of Mr. Evans, the manager in Egypt, and to the general efficiency of the staff.

The Telegraph Construction and Maintenance Company (Limited).

The twenty-third ordinary general meeting of this Company was held on Tuesday, at the offices, 38, Old Broad-street, E.C., Sir Daniel Gooch, Bart., in the chair.

Mr. W. SHUTER (the manager) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Then, gentlemen, I have to move the first resolution, "That the report and accounts of the Directors to the 31st December, 1886, submitted to this meeting, be and the same are hereby received and adopted, and that a dividend of 36s. per share, in addition to the 12s. a share interest or interim dividend paid to 30th June, 1886, be paid on all shares of the Company for the year ended December 31st, 1886, and that such dividend be paid free of income-tax." I need not detain you very long. I will merely call your attention to a few figures, which I dare say you have all studied beforehand. You will see by the accounts that the net profit for the year has been £75,651, after charging interest upon our debentures. To this sum must be added £65,267, brought forward from last year, making a total of £140,918. From this amount is deducted the interim dividend of 5 per cent., paid in July, 1886, amounting to £22,410, and leaving £118,508 to be dealt with. Of this sum the Directors propose to distribute a dividend of £1. 16s. per share, absorbing £67,230, being at the rate of 15 per cent., and making, with the amount already paid, a total dividend for the year of £2. 8s. per share, or 20 per cent., free of income-tax, leaving £51,278 to be carried forward to next account. I am sorry these figures do not show quite so good a result, although not an unsatisfactory one, as the previous year. To enable us to pay the 20 per cent. we have taken about £14,000 from the large balance we carried forward in the previous year. The work that we have done during the year is as follows:—We have laid 2,476 knots of cable, and we have just started a ship—on Saturday, I think—to lay 360 knots of cable in the Red Sea. The work on hand, at the present moment of course, is very little. We can only hope that work will come in as on previous occasions, and that we shall be able to show you good results; but that depends, of course, upon the orders we can get. In addition to the 2,476 knots laid we have made 832 miles of cable, which have been stored away for other companies in different places, but not actually laid. It is kept in stock for repairs; it is rather stock of cable than anything else. It may be interesting to you to know that in round numbers we have laid 96,000 miles of cable during the time we have been a company, which represents a very large part of the cabl s laid. I do not know that I need detain you any further. I shall be very glad to answer any questions. These things come better by questions than a long speech, because there is very little to speak about, but any question any shareholder may wish to ask in reference to the accounts and the report I shall be very glad to answer. I may mention, because some question may be asked, and probably will be, with regard to electric lighting, we, unfortunately, are still litigating the question, and therefore it is not becoming in me to say anything about it. What will be the result I do not know; but it comes again before the judge on Friday week. The result, as far as we know—the effect of the lighting is that the quality of the light and the efficiency there is no question about; it is only a question whether it can be produced by the machinery put there without creating a nuisance to the neighbourhood. That is the only question, I think, that is in doubt, and until the judge decides we cannot tell what will be the result. I therefore move the resolution which I have read to you.

Sir GEORGE ELLIOT, Bart., M.P.: I shall be glad to second it.

Mr. CROFT: I understand your remarks to apply simply to the lighting of Paddington Station.

The CHAIRMAN: Yes.

Mr. CROFT: Therefore, I quite understand the meeting could not expect you to say anything about it, but I should think the meeting would be glad to know if any other experiments are going to be made, or any other contracts with other institutions, like the Great Western Railway. Is that the only contract the company has?

The CHAIRMAN: That is the only contract we have, and I think, until we are quite satisfied about that, we shall hold our hands, and not go into any further liability until we know the result of that, and the cost of it as well.

Mr. CROFT: Do you expect it will be decided in 10 days?

The CHAIRMAN; Well, it stands now for Friday week.

Mr. CROFT: And will that be a final decision?

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The CHAIRMAN: When you get a final decision in the law courts is very problematical. It has been postponed month after month for some time. The lighting has actually been in operation for months.

Mr. SHUTER: Since April last.

The CHAIRMAN: This sort of litigation has been going on; the parties say it is a nuisance and we say it is not.

Mr. CROFT: I do not know why that should deter the Company from entering into other contracts. There may be special reasons in this case. I understand the litigation is going on with people who reside in the neighbourhood. I do not understand that that should prevent the Company entering into contracts with other public bodies.

The CHAIRMAN: I do not think it would deter us if we had a contract we could see our way clearly to. You know we had a concession for lighting St. James's. Well, that Act of Parliament, which ties the hands of public companies, I hope will be set aside soon; but in the meantime we have not thought it wise to embark in lighting St. James's, because we hardly know the position we should be in under the Act; therefore, we have been holding our hands until we could see our way a little clearer. As to the value of electric lighting, the day will come when electric lighting will be the real light of the country I have no doubt at all, but at present we have been rather, I think you will say prudently, holding our hands until we have had experience and can see our way clearly.

Mr. WILLIAM ABBOTT: I think, sir, the majority of those present will commend you for your reticence in not giving too much information as to what you intend to do. You must bear in mind with regard to electric lighting you are surrounded by many competitors, and, as I in former years—I am reminded by Mr. Shuter that this is the twenty-third annual meeting of this Company—remember I used to be persistent in asking questions from you, I have grown old enough now to see that you were wise that you did not answer them, and I think, sir, in the case of the electric lighting, a new enterprise in which we are likely to be embarrassed, and in which you will no doubt distinguish yourselves in exactly the same way as you have in cable manufacture, the less you say the better. At the same time there is no doubt that it is a great field for the Telegraph Construction and Maintenance Company, and you are wise, and I am sure your shareholders will commend you for proceeding with caution, and not rushing into any contracts for the mere sake of experiments, or making installations which are very costly until you gain experience by the mistakes of others. I think you have every cause to be proud, and though I cannot exactly say that this is a Jubilee year for you—it is only the twenty-third year—yet looking at this map, and seeing that you have laid 96,000 miles of cable to the satisfaction of all, I think, sir, the policy you have pursued in the past is the policy for you to pursue in the future.

The resolution was then put and carried unanimously.

The retiring directors and auditors were re-elected, and a vote of thanks to the chairman and directors then terminated the proceedings.

Western and Brazilian Telegraph Company (Limited.)

Report of the Directors, to be presented at the fourteenth ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., on the 8th inst., at 12 o'clock:—

The Directors have already explained by circular their reasons for the change of the Company's year, and, in accordance with such circular, now submit their report and the accounts of the Company for the fifteen months ended 31st December, 1886. The earnings for the twelve months to 30th September amount to £125,253. 7s. 11d., a decrease of £2,143 1s. 6d. compared with last year, arising partly from the general dulness of trade and partly from lower tariffs, which came into operation in May, consequent upon further competition. The Directors are, however, pleased to be able to report a marked improvement in the traffic for the quarter ending 31st December, 1886, which shows an increase of no less than £14,262 as against the same quarter of 1885. The total earnings for the fifteen months amount to £169,882. 0s. 11d. The ordinary working expenses for the twelve months (exclusive of renewals of cable and repairs to the "Norseman") amount to £53,743. 10s. 11d., as against £60,155 19s. 4d., a decrease of £6,412. 8s. 5d. But to form a more correct comparison the sum of £1,800 for depreciation of "Norseman" should be added to the expenses of the twelve months. These would then stand as £55,543 10s. 11d. as against £60,155. 19s. 4d., a decrease of £4,612. 8s. 5d. The ordinary working expenses for the quarter to 31st December amount to £15,088. 6s. 9d., and for the fifteen months £68,831. 17s. 8d. The expenses for the quarter ended 31st December last must not be taken as a criterion of the annual outlay, inasmuch as during this particular quarter, items of expenditure occur which run over the whole year. During last year the ss. "Norseman" was thoroughly repaired at a cost of £6,397. 19s., and the entire amount has been charged to the revenue of the fifteen months. The repairs and alterations placed the vessel in good order and condition and added to her value, consequently the Directors determined not to write off the usual amount for depreciation. The greater portion of the 200 miles of cable (viz., 162 miles) referred to in the last report has been inserted into the system with most satisfactory results, the interruptions during the year having been much fewer than before. The amount thus expended, £15,432. 12s. 7d., has been charged to the renewal fund. Including the amount brought forward from 1885, the balance to the credit of the revenue account for the 15 months is £62,499. 19s. 5d., of which £12,500 has been placed to the renewal fund, leaving £49,999. 19s. 5d., from which the Directors recommend the payment of a dividend of 13s. per share, or at the rate of £3. 9s. 4d. per cent. per annum for the fifteen months, free of income-tax, leaving £4,558. 9s. 5d. to be carried forward. This will give to the preferred ordinary shares £5 per cent. for the fifteen months, or 9s. 4½d. per share, and 3s. 7½d. per share on account of arrears for the year ended 30th September, 1884. This payment, with the additional 9d. per share paid last year to the preferred ordinary shares, reduces to 3s. 1½d. per share the amount in arrear upon these shares to the 31st December, 1886. The Directors, availing themselves of the opportunity of sending stock cable to Brazil, purchased by tender 100 miles of "main" cable, and 10 miles of "shore end" for general repairs. With this cable the "Norseman" returned to Brazil in August last. The retiring Directors are Sir Henry Drummond Wolff and Mr. Earle, who offer themselves for re-election. The auditor, Mr. Weise, retires, and is eligible for re-election.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—We are informed that the directors of this company have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income-tax, for the quarter ended 31st December last, and payable on the 25th inst. The books of this company will be closed from the 18th to the 24th inst., both days inclusive. The traffic receipts for the week ended 25th February amounted to £3,165.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of February amounted to £1,616, as compared with £1,588 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for February amounted to £46,990, as compared with £48,814 in the corresponding period of 1886.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of February amounted to £35,553, as compared with £33,688 in the corresponding period of 1886, showing an increase of £1,865.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended February 25 were £2,622, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ELECTRIC LIGHT FOR TURKEY.—A company has been formed to establish electric works in Constantinople, and to take over a provisional convention granted to Messrs. Shippey Brothers for the exclusive manufacture of incandescent lamps throughout the Ottoman Empire.

THE ELECTRIC APPARATUS CO. (LIMITED) announce that they are about to remove from 58 and 60, Queen Victoria-street, to larger and more convenient premises at 50, Bow-lane, Cheapside, E.C.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. March 2.		Business Done Week Ending March 2. Highest.	Lowest.
Anglo-American	31,	32	31¾	—
Do. Preferred	52,	53	52⅝	52
Do. Deferred	11,	12	11 9-16	11½
Brazilian Submarine	10¾,	11	10⅞	10¾
Cuba	11½,	11¾	11 11-16	11⅝
Do. Preference	18,	19	—	—
Direct Spanish	2,	2½	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	7⅞,	8⅛	8 1-16	7⅞
Eastern Telegraph	10¼,	10½	10½	10 5-16
Do. 6 per Cent. Preference	13,	14	14	13⅝
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	11⅛,	11⅜	11 7-16	11⅛
German Union	8¾,	9¼	9⅛	—
Globe Telegraph and Trust	4⅝,	5	4⅞	4⅝
Do. Preference	11⅝,	11⅞	11 15-16	11⅝
Great Northern	13⅛,	13⅜	13⅜	13⅛
Indo-European	34½,	35½	35¼	—
Reuter's	6¾,	7¼	—	—
Submarine	185,	195	—	— xd.
West India and Panama	⅝,	⅞	13-16	¾
Do. 1st Preference	8½,	9	9	8¾
Western Brazilian	7¾,	8	7 15-16	7 11-16
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	100,	102	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅝,	⅞	⅞	—
Oriental	3-16,	5-16	—	—
United Telephone	12¼,	12¾	12½	12¼

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¼,	3	2⅜	2
Do. (fully paid)	3¾,	4¼	3½	—
Swan	1¼,	1⅝	—	—
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	37,	38	38½	37
India Rubber, Gutta Percha, and Telegraph Works	21,	22	22½	21½ xd.

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NOTES.

TRIESTE.—The harbour of Trieste has been supplied with an extensive arc light installation. The lamps, forty-five in number, were brought into use for the first time on Thursday last.

THE FRENCH RAILWAY JUBILEE EXHIBITION.—We understand that one half of the building of the forthcoming Railway Exhibition at Paris will be lit with electricity by Messrs. Crompton and Co.

ELECTRIC TRAMWAYS.—We notice that Mr. Holroyd Smith is advertising for tenders for the material and work required for the construction of three miles of electric tramway upon his well-known conduit system.

"JOULE'S SCIENTIFIC PAPERS."—We have received from the Physical Society a copy of the second volume of "Dr. Joule's Scientific Papers." This volume contains those papers of which Joule was a joint author.

THE NIAGARA FALLS.—It is stated that an English syndicate has secured the charter granted by the Legislature of the State of New York for utilising the water-power at Niagara Falls for manufacturing and electric light purposes.

CAMBRIDGE.—A photographer in this town has gone in for electric illumination. He has a lamp of 10,000 candle-power suspended over his doorway. The rooms are lit with Edison-Swan lamps, and an arc light classed as 40,000 candles is used with the camera.

LEWISHAM.—On Saturday a temporary installation of arc and incandescent lamps was carried out at the club house of the Lewisham Bicycle Club, by Messrs. Arthur B. Gill and Co., on the occasion of a smoking concert given to celebrate the first run of the season.

ELECTRIC LIGHTING AT WINDSOR CASTLE.—We are requested to state that the paragraph which recently appeared in *Truth* as to the extension of the electric lighting at Windsor Castle is incorrect. Some temporary experimental work has been carried out, but nothing permanent has yet been decided upon.

BLOCKLEY.—Dovedale House, near Blockley, the residence of Lord Edward Spencer Churchill, has been supplied with an installation of electric light, motive power being obtained from a turbine placed in an adjoining stream. The dynamo is by Elwell-Parker, and the turbine by Messrs. Ball and Horton, of Stratford-on-Avon.

UNDERGROUND TELEGRAPH WIRES.—We are informed that the Commissioners of Sewers have decided to refuse permission for any more wires to be laid under the streets of the City of London. We are at a loss to understand to whom this refusal can apply. Not to the Post Office, certainly; and we were not aware that any private company are at all desirous of laying their wires underground.

YNISHIR, SOUTH WALES.—The "Standard" Colliery at Ynishir, South Wales, has recently been supplied with an installation of electric light by the Gülcher Company, consisting of 65 Edison-Swan lamps of 16 candle-power, of which 30 are underground, and one Gülcher arc lamp, on the surface, of 3,000 candle-power. The dynamo is of the No. 2A Gülcher type, and is driven by a high-pressure engine of 5 horse-power nominal.

ELECTRIC COMMUNICATION WITH LIGHTHOUSES.—The committee appointed to consider the question of electrical communication between lightships and lighthouses and the shore, held the first meeting last week at the Board of Trade, the Earl of Crawford presiding. It was arranged to meet this week to hear evidence, the first witnesses being certain officials of the Trinity Board. Afterwards officials from lightships will be examined.

THE ELECTRIC LIGHT AT THE ELYSÉE.—At a ball recently given by President Grévy the electric light was for the first time employed, 330 Swan lamps being supplied with current from a battery of 660 "Jarriant" accumulators. A French journal states that the improvement was highly appreciated by all present, "inasmuch as uncomfortable recollections are entertained of previous festivities at the Elysée, when drops of wax fell not unfrequently upon bare shoulders."

BRUSSELS.—The Grand Hotel at Brussels is now lit throughout by electricity, and the installation is by far the most important at present existing in Belgium. The number of incandescent lamps exceeds 1,200, in addition to which there are 14 arcs of 600 candle-power. The work has been carried out by MM. L. Gérard and Co., of Brussels. The current is supplied by two slow-speed "Gérard" dynamos, driven at 500 revolutions direct from the fly-wheel of a Corliss engine.

THE POST OFFICE AND OVERHEAD WIRES.—In the House of Commons on Monday last, Mr. Barry asked whether any resolution had been come to with regard to overhead wires. Mr. Raikes said the question had been forced upon the attention of the department by the recent snowstorm, which caused so much injury to the wires. The extension of the underground system was, however, opposed by the professional advisers of the department on the ground of its very great expense.

THE HOUSE OF COMMONS.—We regret to learn that great inconvenience was caused at the House of Commons last Friday night through the electric light having suddenly failed all over the building. The old oil lamps, which have been discarded for five or six years, had to be brought into use. The cause of failure (as has generally been the case in the limited number of similar instances of failure) proved to be mechanical, and not specifically electrical—a boiler tube had given way. But it is decidedly wrong that an installation of this character should be dependent on a single boiler.

THE TELEPHONE IN VICTORIA.—The following note appears in the *Australian Times*:—"On January 13 fresh complications arose between the Postmaster-General and the directors of the Victorian Telephone Exchange Company, and the latter declined to proceed with the proposed arbitration. The Postmaster-General decided to telegraph to the Agent-General to recall the Deputy Postmaster-General, who is now on the Continent, to consult with him as to the best appliances to be procured for use at a Government Telephone Exchange. It is probable that the department will lay a telegraph cable and wires underground."

SIXPENNY TELEGRAMS.—In the House of Commons, on Monday last, upon the supplementary vote of £122,000 for the Post Office telegraphs, Mr. Shaw-Lefevre asked if the Postmaster-General could make any statement as to the increase in the revenue for the working of the 6d. telegram system. Mr. Raikes said it had been estimated that there would be a loss of £10,000 or £20,000 on the present year owing to the introduction of the 6d. telegram system, but it turned out that instead of a loss there would be gain of £80,000, or, in other words, that the actual revenue would be £100,000 more than the estimated revenue.

THE "JOURNAL" OF THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The issue of this *Journal* which

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has just made its appearance, is one of unusual interest and importance, containing as it does the paper by Mr. Kapp "On the Predetermination of Dynamo Characteristics," and the discussion thereon, which extended over three evenings. The discussion, as printed, will be found to contain some additional matter which is of considerable importance—particularly the mathematical expressions now given by Prof. Forbes and Prof. Ayrton. There is also in the appendix a valuable letter on the same subject from Mr. Guy C. Fricker.

INSULATING DYNAMO MACHINES.—"In many electric light stations," says the *American Engineer*, "wires are run on the brickwork or on a cement floor. Bricks and ordinary cement are exceedingly porous, and if water reach any part the whole becomes somewhat damp. Dynamos are placed directly over such a floor, and the intervening wooden base may become damp enough to make quite a dangerous ground at the machine, in case, as often happens, there is connection on some part of the field magnets with the wire. It is stated that by thoroughly drying the brick and cement work, and saturating it with asphalte, applied boiling hot with a brush, it will be found that the dampness can be prevented and good insulation insured."

THE TELEPHONE BREAKDOWN.—The following letter appeared in the *Daily News* of the 10th inst.:—"Will you kindly allow me a small space in order to protest against the extraordinary delay on the part of the United Telephone Company in restoring communication by telephone in London? Since the evening of the great snowstorm of December 26, which caused so much damage to the overhead wires, little has been done, especially in this neighbourhood, to restore the wires. In our own case a private wire between Kensington and Paddington remains in the same condition as it did ten weeks ago. In this parish, in the vicinity of the Great Western Railway, the wires are still down in every direction, and no attempt has yet been made to repair them."

THE ELECTIC LIGHT IN THE PARIS THEATRES.—The Prefect of Police at Paris has issued some regulations with regard to electric lighting in theatres. The employment of bare arc lights is very properly prohibited. A tray is to be placed below the globe in order to catch any loose pieces of carbon, and the globe itself is to be surrounded with a metallic net work. This also is perfectly reasonable, but when a similar regulation is applied to incandescent lamps it strikes us as being unnecessarily stringent. The rules require that all incandescent lamps are to be provided with a metallic network surrounding the globe in order to prevent fragments of glass from falling upon any one underneath. If such a rule is required at all it should certainly be applied equally to globes surrounding gas flames, which are far more liable to fracture than are incandescent lamps.

A HARD NUT.—A correspondent would like to know, if A. B. designs a new motor of some kind, and C. D. uses that motor to haul a wire rope, whether such combination would form a valid patent, and, what is infinitely more important to him, could he claim and would he obtain "honour scientific" by so doing? Our reply is that anything is a valid patent nowadays—till some one else gets a patent for the same thing; and that "honour scientific," whatever that may be, is to be had for the asking (*sotto voce*, and paying). No, sir; if you are a Russian, Italian, or American, just come to London Town, say you have got a wonderful invention, too simple to patent, too simple to let anyone see how it is done; do a little work secretly on the fifth floor back, or buy the specimens of work already done, show the city folk, and make your thousands, while good honest work is set aside without a possibility of getting a fifty-pound note to put it straight.

A POCKET DANIELL.—Dr. Edelmann, of Munich, has recently devised a convenient little pocket Daniell battery consisting of two pairs of zinc and copper plates, each 12 cm. by 7, separated by sheets of prepared Swedish filter paper. The paper is prepared by dipping it into a hot solution of gelatine and then covering it on one side with powdered sulphate of copper, and on the other with powdered sulphate of zinc, drying and cutting it to the size required. When required for use the paper is steeped for a few moments in water until the gelatine is softened, and the sheets are then laid between the metal plates, and the whole fastened together by india rubber bands. The battery has an E.M.F. of 2·04 volts, and gives through an external resistance of 1 ohm a fairly constant current of ·5 ampere, and is very useful for such purposes as the determination of resistances or the detection of faults of insulation. The battery, with binding screws attached and a supply of prepared paper, is sold for five shillings.

BRIGHTON.—The *Brighton Times* recently devoted a column to the report of an "interview" with Mr. Arthur Wright, the managing director of the Brighton Electric Light Company. Our readers will remember that the Brighton installation is worked upon a series circuit, with constant current and automatic cut-outs. It is satisfactory to learn from the report of the local journalist that the installation ran for four years up to October last without a single breakdown. On the date referred to a new engine was tried, and a leaky pump-valve rendered it necessary to stop during the early part of the evening for repairs. Meters of the Edison type are in use, and are found to work satisfactorily. The plant at present in operation is capable of supplying the requirements of an installation of 6,000 lamps. We may add that we have recently received from the company a very neatly got up little pamphlet, entitled "The Advantage of the Electric Light, and How to Obtain it in Brighton and Hove," and containing full particulars as to cost, &c., with a number of illustrative examples.

THE BERLIN TELEPHONE SERVICE.—London is not, after all, the only town where the telephone service gives rise to general dissatisfaction. Complaints of a similar character are rife in Berlin. The Chamber of Commerce has recently presented a petition to the Administration of Posts and Telegraphs setting forth their grievances in this matter. They complain of the delay in establishing communications, of frequent breaks-down upon the lines, of the indistinctness of speech, and, lastly, of the weight of the receivers. The instrument in use is the Siemens telephone, which contains a horse-shoe magnet, and weighs nearly twice as much as an ordinary Bell. It will probably surprise many people to learn that similar instruments are used as transmitters. This fact undoubtedly goes a long way to account for the defective speaking. The Berlin Exchange numbers over 6,000 subscribers, and is connected with nine sub-exchanges in different parts of the city. The wires are all overhead; the Administration of Posts and Telegraphs proposed at first to place them underground, but permission to dig up the streets was refused by the Municipal Authorities. The Administration retaliated by refusing to connect any of the market places with the exchange. This is a very pretty quarrel, but in the meantime the public, as usual, has to suffer for it.

THE HERZ TELEPHONE.—The daily papers have been publishing some remarkable telegrams from Paris as to the performance of a telephone transmitter recently introduced by

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Dr. Herz. M. Blowitz, in *The Times*, devotes nearly half a column to the subject, and is convinced that "it introduces a complete change in our ordinary modes of intercourse." The mode of operation, as described by M. Blowitz, is also worth quoting verbatim. "When the button has been pushed in, and has made a sound at the other extremity it is taken out, and is found to be attached to a long electric wire—there is thus exposed the telephonic plate, which is extremely sensitive." The *Daily News* account is as follows:—"Experiments have been made between Paris and Brussels, a distance of over 200 miles, with a new telephone, invented by an American, Dr. Cornelius Herz. The entire apparatus is remarkably compact, and though scarcely bigger than an ordinary electric push button, transmits the human voice as efficiently as the best microphones in general use at present. The engineers of the French and Belgian telegraph departments, who tested this microscopic telephone system, as it is called, have pronounced it to be a decided improvement on the old and cumbrous contrivance. Every word of a conversation which lasted over an hour was rendered with remarkable distinctness, and throughout the experiment there was not a single hitch. It appears that this tiny apparatus can be produced for less than half-a-crown. The simplicity of its mechanism is such as to ensure durability." The *Pall Mall Gazette*, with its usual enterprise, promptly despatched an "interviewer" to obtain the ideas of the United Telephone Company on this momentous episode. It appears, however, that the company retains its equanimity, and hopes to show that this latest "discovery" will have to be classed with the usual "scientific" announcements of the daily press.

THE NEW THAMES TUNNEL RAILWAY.—The construction of the new underground line which is to extend from King William-street, under the bed of the river, to the "Elephant and Castle" is being pushed on with great vigour. The boring under the Thames has now been completed, the work having occupied only sixteen weeks (as compared with 18 years for the first Thames Tunnel). Power is being sought to extend the line from the "Elephant and Castle" to the "Swan" at Stockwell. The distance already authorised is 1½ mile; the contemplated extension would bring up the total length of the line to 3¼ miles. Now, under these conditions, we venture to suggest to the engineers of the company that they would do well to consider whether this addition to the length of the line does not bring with it the desirability of an alteration in the proposed method of working. An eminent authority, after full examination of the general question, has recently laid down the following dictum:—"When power is to be transmitted over a distance *less than one mile* wire rope transmission should be employed; but for distances *from one mile up to two or three miles* electric transmission is the more economical." It would thus appear that while the decision to employ wire rope haulage was in the first case fully justifiable, it now becomes a question whether an important economy would not be effected by the substitution of electric transmission. A further consideration of great importance is that of the adaptability of either system for future extension. And here there can be no doubt whatever that electricity bears off the palm. In the United States experience has shown that however satisfactory wire rope haulage may be on a single straight line, yet no sooner is it attempted to work branch or junction lines than the difficulties are indefinitely increased. If, however, electric transmission were employed, the question of future extensions would present no difficulty whatever. We may also add that it would be a mistake to consider the introduction of electric working for a line of this description in the light of an experiment. The number of electric railways in existence certainly exceeds fifty, and difficulties have been successfully overcome which far exceed any that can possibly occur upon a line of this description, protected from all climatic disturbances.

THE OLD WORLD *is* PLAYED OUT.—A friend has sent us a copy of a paper called the *Industrial Review*, conducted by Edw. David Hearn, M.A., D.C.L., C.E., &c. We conclude that electrical knowledge is depicted by the "&c.," which always stands for a lot, and is more expressive than the unknown quantity X, hence we must be careful of criticising adversely this unknown power, which may, to our sorrow, turn upon us and crush us on account of our ignorance. We are glad to find that the *Industrial Review* is successful; at any rate, its motto is that "Nothing succeeds like success." The readers must, we imagine, be easily satisfied; but then, we are told elsewhere babes are fed with milk. Yet even babes kick at sour milk. Our contemporary devotes a column to a "mare's nest"—we beg pardon, to the discovery by a Philadelphia lawyer of an "economic generation of electricity for industrial purposes" in the condensation of steam, preferably at a low temperature. Verily the discovery is worthy of the Philadelphia lawyer, and suited to the not over strong constitutions of the readers of the *Industrial Review*. This ingenious lawyer takes a lot of "Leyden jars"—preferably little ones—charges them and discharges them into a main with rapidity. The lot of little Leyden jars may be used to charge another lot of Leyden jars (preferably further along the line), and the last-mentioned jars be used to supply the working line. "The ultimate *reservoir* (Oh! printer, put this word in italics) for the electricity from the jars is to be the earth." In another sentence we are told, "An ice box or compartment is arranged about the dome of the condenser, and in summer is used to keep the dome cool and facilitate the condensation of steam." We have also a discharging rotating steam nozzle and other apparatus directly or incidentally referred to. No doubt the Philadelphia lawyer is on his way to England to sell to someone in the city this remarkable invention. If we might advise him we should say carry it to *The Times*, and no doubt a most extraordinary account of the invention would appear in that paper. But after *The Times*—the deluge. An economical means of generating electricity, forsooth. We in all modesty and humility must venture to doubt the economy, and we could suggest to the Philadelphia lawyer and his editorial supporters that they might, with some advantage to themselves, study the past work of Sir W. Armstrong in this direction.

ELECTRIC LIGHTING OF PUBLIC BUILDINGS IN BIRMINGHAM.—At a meeting of the Birmingham Town Council on Tuesday, the mayor read a letter from Mr. Arthur Chamberlain on behalf of the Midland Electric Light and Power Company, asking the committee to consider a proposal for the extension of the electric lighting of the round room at the Art Gallery to other rooms in the building. The company would be willing to provide, fix, and run at their own cost the requisite engines, dynamos, and other plant, and take all the responsibility connected with them, supplying the Art Gallery at a fixed charge per lamp per annum if, in addition to the Art Gallery, the Town Council would grant them the right to light the Town Hall. With these two arranged for, the company could obtain a portion of the lighting of other public buildings in the immediate vicinity, and thus spread their establishment charges over something like 1,200 lights. The company would supply the light in the Art Gallery for £1 per lamp per annum for as many hours as the committee liked from dusk to 9 p.m., and for as many evenings a week as they wished. If they used

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them six nights a week, as they probably would do as soon as they had the electric light, it would be as cheap as or cheaper than gas, for the same amount of light. All the present leads, lamps, and reflectors in the round room would be utilised, while the sale of the engine and dynamo would realise enough to pay for the wiring of the other rooms. The advantage of this arrangement to the Art Gallery, avoiding, as it did, all capital outlay, attendance, and risk, would be seen, and the Company were prepared to offer equal advantages to the users of the light in the Town Hall. At present the latter had to pay £10 a night for the electric light, including the use of lamps and electroliers, but not including the charge for gas in various parts of the hall. There were in consequence of this high charge many complaints and few users. The company was prepared to supply it in the same way for a charge of only £5 per night.—The Mayor, in moving that the communication be referred to the General Purposes Committee, said that the matter was one which interested several committees, and would be better dealt with by the General Purposes Committee, upon which all of them were represented.—The motion having been seconded, Mr. Brinsley said the letter looked like an advertisement of something which was in competition with the Gas Committee, and the less encouragement they gave to it the better for the borough.—The motion was carried.

MEETING OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION OF THE UNITED STATES.—Detailed reports of the recent meeting of this important body have now come to hand, the *Electrical World* of New York devoting the whole of its space to the papers and discussions. The Association is eminently a practical body, and does not meet to discuss scientific, or scarcely even technical questions. It is concerned chiefly with the consideration of how best to make electric lighting a paying concern, and its leading idea is "business." Consequently, in the present state of electric lighting in this country, hoping as we do for a speedy amelioration of the present legal disabilities, the topics discussed by the Association should have for us an especial interest. Unfortunately, however, we have personally felt some disappointment in looking through the proceedings ; a great part of the time of the Association was spent in the discussion of subjects which are of little or no interest beyond the American borders, such as the reform of their own laws, and questions of patents and gauges, whilst other papers, whose titles are sufficiently promising, were dealt with in a way which adds but little to our knowledge of the subject. In several instances the debates proved, for our own purpose, to be of far greater value than the paper ; this was notably the case with regard to the discussion on electric motors, which we intend shortly to reproduce. A paper read by Mr. C. C. Haskins on "High Insulation" was occupied with the useful and no doubt necessary work of insisting upon better insulation for arc light circuits. It did not itself contain any special information upon the subject, but in the course of the discussion which followed Mr. F. A. Mason moved the following resolutions :—

"*Resolved.* That a commission of five members of the National Electric Light Association be appointed whose duty shall be:

"*First.* To determine what qualities are essential to good insulation for electric light wires.

"*Second.* To examine such insulation as may be submitted to it, and to determine in what degrees the different insulations submitted possess the virtues required.

"*Third.* To report at the next meeting of the Association the results of their investigations."

Some opposition was made to the second resolution, a member insisting that the Association had no more business to determine which was the best kind of insulation than they had to say which was the best dynamo or the best arc lamp. The resolutions were, however, carried in their original form, and the committee was constituted as follows:—Prof. E. J. Houston, M. M. Garver, R. T. Robinson, Carl Hering, and Prof. W. D. Marks. These names are themselves a sufficient guarantee that the question will be dealt with in a thoroughly efficient manner. Another paper, which we hope to find space to reproduce, is one by Mr. A. F. Upton, entitled "Plans for Installing Central Stations," dealing, however, entirely with mechanical details.

ELECTRIC LIGHTING IN LEEDS.—A recent number of the *Leeds Mercury* contained the following interesting paragraph : "Several years have now elapsed since the electric light was first practically introduced into this borough ; and it will be interesting to our readers, and will serve to mark the progress of a phase of civilisation among us, if we give approximately the numbers of machines, lamps, &c., at present available or in use in Leeds. Of electric light dynamos of various sizes and descriptions there are about thirty-five, besides several kept for occasional use. Primary batteries for lighting are at present only resorted to for medical and theatrical purposes, and for private amusement. Secondary batteries, or "accumulators," are employed at present only to a very limited extent, but up to the present give great satisfaction. Over 130 arc lamps of various kinds are in more or less regular use, chiefly in engineering works, factories, dye houses, and colour-printing works, where their pure white light enables work to be continuously done that otherwise could only be done at intervals with bright daylight. Of incandescent lamps there are about 2,600, but the machinery is only equal to working about 2,000 at any one time. Incandescent lamps are used in the Public Library Department of the Municipal Buildings with complete success, save that more lamps in certain parts would be an advantage. There is an easy possibility of partial lighting during the daytime of that side of each room which most needs it, where, we are sorry to say, gas is burnt with manifest disadvantage, the effect of gas on books and decorations being ruinous. Incandescent lamps are also used, when required, in the Victoria Hall, at the musical festivals, &c. The Colosseum Company, ever since the opening of their fine building, have had a most complete installation of incandescent lighting at work on the premises with full satisfaction. The lecture hall and library of the Philosophical Hall are lighted by incandescent lamps from dynamo or accumulator. The Albert Hall is partially lighted occasionally from an accumulator. At the Yorkshire College, in a well known bank, in two flour mills, extensive business premises near Boar-lane, and in several private houses, offices, and shops, these lamps are used, always giving satisfaction when properly fitted up and steadily worked. 'Anything that is worth doing at all is worth doing well;' and this applies with great force to electric lighting. It is unreasonable to expect satisfaction unless the work is carried out properly, and this can only be done by qualified men, adequately paid. The first cost is the chief expense, and here it is that people sometimes made the mistake of putting lowness of price before anything. Electric lighting is one of the greatest advantages we can possess in the way of illumination. Even if a little more costly than other lights, its beauty, purity, steadiness, with its low heating effect, give it an unapproachable superiority over every illuminant which it has been within the power of human ingenuity to produce."

PROF. HOUSTON ON THE FUTURE OF ELECTRICITY.—At the recent meeting of the National Electric Light Association of the United States Prof. Houston made the following remarks:

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"It seems to me of all the bright future which seems to be in store for us, as those interested in electrical matters, that in the direction of electric motors the sky appears to be the brightest. For, when we bear in mind the economy which is possible in the electric motor (and I was glad to hear Mr. Sprague speak in such unqualified terms respecting it), when we consider the very great economy of the electric motor, its small bulk, and the wonderful power it is capable of rendering, it seems to me that comparatively little is needed in order to permit the steam engine to become a thing of the past, and the dynamo electric machine become the motor of the future. Of course, as we all know, such a state of things would be impossible as long as we have to rely upon the steam engine as a prime motor to furnish the electric current; but I take it that inventive genius will not be found long wanting to devise a practical means whereby the burning of coal can be directly applied to the production of electricity; and as soon as that is accomplished, then beyond any question the steam engine becomes a thing of the past, a toy, an historical piece of apparatus. And ye, fellow workers, know what that means; ye, engine and boiler men know what that means—when you can pack on a small floor space a machine capable of developing three, four, five, six, seven thousand horse-power if you only have the wherewith to put into it. I think the chances are that that will be solved. I think the chances are good, and that it will be made when one succeeds in solving the problem of how to change a current of low electromotive force into one of high electromotive force. It is recognised to-day that coal can be burned to produce electrical power, and I do not think it requires any great prophetic power, looking into the future, to see that this is not only a possibility but a probability—and of the near future. I confidently expect to live to see it. When it was proposed to cross the Atlantic by means of steam, it was shown beyond peradventure by the very best mathematical ability, by the highest engineer authorities in the world, that it would clearly be impossible for a vessel ever to cross the Atlantic Ocean by means of steam, because, as it was argued and proved, the coal necessary to supply such a vessel would sink the ship. Now, gentlemen, on exactly the same plan, is it not true—will you excuse me if I vaporise a little—that the only thing that stands in the way of aërial navigation to-day is compact motor power? We can certainly fly, and we can certainly navigate the air, not by means of balloons, but by some motive power, if we can get a compact motor. It seems to me not only possible, but very probable, that the electric motor may solve this particular requirement. It may not be impossible that we shall live to see flying. I certainly expect not to fly myself, as that would require considerable power, but to see machines carrying their passengers through the air. It does seem to me that of the attractions of this field, the most practical and the one in which the future is brightest to us, is in the direction of electric motors; and I believe, too, in electric motors on arc light circuits, even electric motors in series as well as electric motors on constant potential circuits."

Some Curious Facts.—In the last issue of the *Journal* of the Society of Telegraph-Engineers the following letter from Prof. Moses G. Farmer to Prof. Hughes is published:—"My Dear Prof. Hughes: I have taken great interest in your researches into the phenomena of self-induction as manifested in different metals, and in the practical application of these discoveries; and I trust that you will pardon me for bringing to your notice one or two curious facts that have come under my own observation. When I had built the Fire Alarm Telegraph in Boston, some time in the summer of 1852, I think it was, one of the signal-circuits was struck, and one or more of the electro-magnets in the signal-boxes had the wire with which they were wound (No. 23 B.W.G.) burned off. After testing the circuit carefully, and having mended all the breaks, we were still unable to charge the signal-magnet for some long time, perhaps three or more hours, the magnets seeming to have been paralysed so as to be unable to receive a charge of magnetism; but after a time, perhaps before the next day, they recovered their tone, so to speak, and, worked well afterwards. I am not quite sure whether this occurrence was repeated or not; if it was, I could possibly find account in my notes at the time. Another interesting occurrence was in the City of New York, in the year 1870, if I mistake not. The city was then having many miles of compound steel and copper telegraph wire strung from one signal box to another; three of these wires ran over the Deaf Mute Asylum at Carmansville, but had not yet been connected to the signal boxes for which they were designed. The lightning struck the building, cut off a cast-iron water pipe that was some three inches in diameter, and let all the water out of the tank that was in the attic of the four story building. It also burned off one or more of these three wires, and from one, at least, it stripped all the copper for a distance of more than one hundred feet, leaving most of the copper in small bits, more or less than half an inch in length, lying on the ground, but leaving the steel wire unharmed, and as bright as a new tin pan. The compound wire had been made by drawing the steel wire through a bath of melted tin, then drawing a ribbon or skelp of copper over the tinned steel. Lastly, the copper was sweated to the steel by drawing the compound wire through melted tin. This stripped steel wire, with its coating of tin, remained bright for more than a day, but after that time it began to rust, and was soon replaced by a new wire. I remember that somewhere about that time an iron wire in the eastern part of Massachusetts was struck by lightning, and for many rods it was melted into short pieces, which dropped upon the ground beneath the wire, and were found lying there by the line repair-man. I remember that in my early experiments in electric lighting, about the year 1859, I was trying a wire of aluminum for incandescent purposes. I was using a piece of wire that was perhaps five or six inches in length, and possibly three-hundredths of an inch in diameter, or a little more. The wire was suspended in form of a loop, and by means of a rheostat the current was increased until the light was very bright. I noticed that it was quite flexible, or rather flexile, for it had no elasticity, behaving in this respect in an entirely different manner from a wire of platinum. I heated and cooled it two or more times. I then noticed that it seemed shrivelled, somewhat like in appearance a shed snake skin. I punctured the wire with a fine steel needle, and withdrawing the needle there followed a stream of melted aluminum to a length of rather more than the quarter of an inch. This metal cooled immediately, and remained sticking out from the wire after the current had been withdrawn. I suppose that the outer surface of the heated wire became oxidised, and, perhaps, hydrated, and in this condition had sufficient tenacity to hold together with its interior in a state of fusion, while its exterior was solid. While this loop was in this condition, solid without, but fused within, I presented a small steel magnet towards it, and the loop waa immediately attracted in virtue of the magnetic effect of the current; the presented pole caused the loop to twist so that its sides came together, short-circuiting itself, and thus burning off at the junction. I tried other wires, some of platinum, some of copper, and some of iron, but could not succeed in fusing them in the interior and have the surface remain solid. I did not try magnesium, not at that time having any on hand. I have often thought it would be interesting to try it."

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXVII.

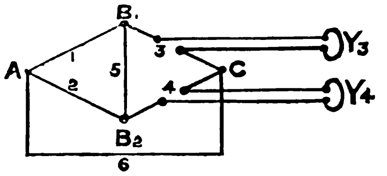
BY OLIVER HEAVISIDE.

(Continued from page 283.)

General Theory of the Christie Balance. Differential Equation of a Branch. Balancing by Means of Reduced Copies.

It is not easy to find a good name for Mr. S. H. Christie's differential arrangement. There are objections to all the names bridge, balance, lozenge, parallelogram, quadrangle, quadrilateral, and *pons asinorum*, which have been used. It seems to be a nearly universal rule for words, used correctly in the first place, to gradually change their meaning, and finally cause us to talk nonsense, according to their original signification. Thus the Bridge is the conductor which bridges across two others. But it has become usual to speak of the differential arrangement as a whole as the Bridge; and then we have the four sides of the bridge, which is absurd. Quadrilateral is the latest fashion. It has four sides, truly. But there are six conductors concerned; so we should not call the differential arrangement itself the quadrilateral. I propose to simply call it the Christie, without any addition, just as telegraphers speak of the Morse, or the Wheatstone, meaning the apparatus taken as a whole. Thus we can refer to the Christie, the quadrilateral, and the bridge, the latter two being parts of the former. This will suppress the farrago.

In the usual form of the Christie we have four points, A, B_1, B_2, C, united by six conductors, numbered from 1 to 6 in the figure. The quadrilateral has the four sides, 1, 2, 3, 4. The bridge wire is 5, joining B_1 to B_2, and 6 is the battery wire. The battery current goes from A to C by the two distinct routes AB_1C and AB_2C. Some of it crosses the bridge, up or down; except under special circumstances, when the bridge wire is free from current, which is the useful property.



Let us generalise the Christie thus:—Let the sole characteristics of a branch be that the current entering it at one end equals that leaving it at the other, with the additional property that the electro-magnetic conditions prevailing in it are stationary, so that the branch becomes quite definite, independent of the time.

Thus, all six branches may be any complex combinations of conductors and condensers satisfying these conditions. The communication between the two ends of a branch need not be conductive at all; for example, a condenser may be inserted. As an example of a complex combination, let branch 3 consist of a long telegraphic circuit, symbolised by the two parallel lines starting from 3 and ending at Y_3, where they are connected through terminal apparatus. This branch then consists of a long series of small condensers, whose + poles are all connected together by one wire, and the − poles by the other wire. There is also conductive connection (by leakage) between the two wires. There is also electro-magnetic induction all along the line. But, as the current entering the line from B_1 to 3, and that leaving it, from 3 to C, are equal, the telegraphic line comes under our definition, provided it be stationary in its properties. Observe that this does not exclude the presence of other conductors, between which and the line in branch 3 there is mutual induction, providing this does not disturb our fundamental property of a branch. We may, indeed, remove the original restriction, but then it will no longer be the Christie, for more than *four* points will be in question. Suppose, for example, there is mutual induction of the electrostatic kind between branches 1 and 2, which is most simply got by connecting the middles of 1 and 2, taken as resistances, through a condenser. Then there are *six* points, or junctions, concerned, and a slight enlargement of the theory is required.

Let us now inquire into the general condition of a balance, or of no current in the bridge wire due to current in 6, which, therefore, enters the quadrilateral at A and leaves at C, and which may arise from impressed force in 6 itself, or be induced in it by external causes. First, as regards the self-induction balance in the extended sense. This does not mean that each side of the quadrilateral must be equivalent to a coil, but merely that the four sides are independent of one another in every respect, except in being connected at A, B_1, B_2, C. Thus we can have electrostatic and electromagnetic induction in all six branches, but independently of one another. Under these circumstances it is always possible to write the differential equation of a branch in the form $V = ZC$, where C is the current (at the ends), V the fall of potential from end to end, and Z a differential operator in which time is the independent variable. When the branch is a mere resistance R, then $Z = R$, simply. When it is a coil, independent of all other conductors, then $Z = R + Lp$, where L is the inductance of the coil, and p stands for d/dt. When it is a condenser, then $Z = (Sp)^{-1}$, where S is the capacity. If the condenser have also conductance K, or be shunted by a mere resistance, then $Z = (K + Sp)^{-1}$. These are the simplest cases merely. In general, Z is a function of p, p^2, &c., and electrical constants.

Now let the positive direction of current be from left to right in sides 1, 2, 3, 4, and suppose we know their differential equations $V_1 = Z_1C_1$, $V_2 = Z_2C_2$, &c. To have a balance, so far as the current from 6 is concerned, the potentials at B_1 and B_2 must be always equal, except as regards inequalities arising from impressed forces in other branches than 6, with which we are not concerned. Therefore

$$\left.\begin{aligned} V_1 &= V_2, \quad \text{and} \quad V_3 = V_4, \\ \text{or,} \quad Z_1C_1 &= Z_2C_2, \quad \text{and} \quad Z_3C_3 = Z_4C_4, \end{aligned}\right\} \qquad (1c)$$

But, $\quad C_1 = C_3, \qquad C_2 = C_4,$

So, using these in (1*c*), we get

$$\left.\begin{aligned} Z_1 C_1 &= Z_2 C_2 \\ Z_3 C_1 &= Z_4 C_2 \end{aligned}\right\} \quad \ldots\ldots\ldots \quad (2c)$$

Eliminate the currents by cross-multiplication, and we get

$$Z_1 Z_4 = Z_2 Z_3, \quad \ldots\ldots\ldots \quad (3c)$$

which is the condition required. It has to be identically satisfied, so that, on expansion, the coefficient of every power of p must vanish.

If we take $Z = R + Lp$ (as when each side is a coil, or equivalent to one), we obtain the three conditions given in my paper "On the Use of the Bridge as an Induction Balance," *Electrician*, April 30, 1886, p. 489, equations (1), (2), (3).

As another example, take $Z = (K + Sp)^{-1}$ (shunted condensers), and we obtain three similar conditions. But it is needless to multiply examples here. We have only to find the forms of the four Z's, expand equation (3*c*), and equate to zero separately the coefficient of every power of p. It does not follow that a balance is possible in a particular case, but our results will always tell us how to make it possible, as by giving zero values to some of the constants concerned, when one branch is too complex to be balanced by simpler arrangements in other branches.

The theory of a balance of self and mutual electro-magnetic induction I propose to give by a different and very simple method in the next section. At present, in connection with the above generalised self-induction balance, let us inquire how to balance telegraph lines of different types, or when they can be simply balanced. It is clear, in the first place, that if we choose sides 1 and 3 quite arbitrarily, we have merely to make side 2 an exact copy of side 1, and 4 an exact copy of side 3, in order to ensure a perfect balance. Imagine the bridge wire to be removed; then we have points A and C joined by two identical arrangements. The disturbances produced in these by the current from 6 must be equal in similar parts; hence, if B_1 and B_2 be corresponding points, their potentials will be always equal, so that no current will pass in the bridge wire when they are connected. But we can also get a true balance when the "line" AB_2C is not a full-sized,

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but a reduced copy of the line AB_1C. It is not the most general balance, of course, but is still a great extension upon the balance by means of full-sized copies. The general principle is this:—

Starting with sides 1 and 3 arbitrary, make 2 and 4 copies of them, first simply qualitatively, as it were; thus, a resistance for a resistance, a condenser for a condenser, and so on. This is like constructing an artificial man with all organs complete, but in no particular proportion. Then, make every resistance in sides 2 and 4 any multiple, say s times the corresponding resistance in sides 1 and 3. Make every condenser in sides 2 and 4 have, not s times, but s^{-1} times the capacity of the corresponding condenser in sides 1 and 3. And, lastly, make every inductance in sides 2 and 4 be s times the corresponding inductance in sides 1 and 3. This done, s being any numeric, AB_2C is made a reduced (or enlarged) copy of AB_1C, and there will be a true balance. That is, the *potentials* at corresponding points will be equal, so that the bridge wire may connect any pair of them, without causing any disturbance.

Now let a telegraph line be defined by its length l, and by four electrical constants R the resistance, S the electrostatic capacity, L the inductance, and K the leakage conductance, all per unit length. It is not by any means the most general way of representation of a telegraph line, but is sufficient for our purpose. Let C be the current, and V the potential-difference at distance x from its beginning. We require the form of Z in $V = ZC$ at its beginning. This will depend somewhat upon the terminal conditions at the distant end, so, in the first place let $V = 0$ there. Take

$$C = \cos mx.\, A + \sin mx.\, B \quad . \quad . \quad . \quad . \quad (4c)$$

$$V = -(R + Lp)m^{-1}(\sin mx.\, A - \cos mx.\, B) \quad . \quad . \quad (5c)$$

$$-m^2 = (K + Sp)(R + Lp) \quad . \quad . \quad . \quad . \quad (6c)$$

p standing for d/dt as before. These are general, subject to no impressed forces in the line. A and B are arbitrary so far. But at the end $x = l$, we have $V = 0$ imposed, which gives, by (5c),

$$B/A = \tan ml, \quad . \quad . \quad . \quad . \quad . \quad (7c)$$

so that at the $x = 0$ end, we have, by (4c), (5c), and (7c),

$$\frac{V}{C} = \frac{R + Lp}{m} \cdot \frac{B}{A}; \text{ or } Z = (R + Lp)\, l.\, \frac{\tan ml}{ml}. \quad (8c)$$

This is the Z required. From the form of m^2, we see that if the total resistance Rl and total inductance Ll in one line be, say, s times those in a second, whilst the total capacity Sl and total leakage conductance Kl in the second line are s times those in the first, then the values of ml are identical for the two lines. If these lines be in branches 3 and 4, we therefore have

$$\frac{Z_3}{Z_4} = \frac{(R_3 + L_3p)l_3}{(R_4 + L_4p)l_4} = s, \quad . \quad . \quad . \quad . \quad (9c)$$

so that we may balance by making sides 1 and 2 resistances whose ratio R_1/R_2 is s; or if coils be used, by having additionally $L_1/L_2 = s$; or if condensers are used $(K_2 + S_2p)/(K_1 + S_1p) = s$; and so on.

But if there be apparatus at the distant end of the line, it must also be allowed for. Let $V = YC$ be the equation of the terminal apparatus; that is, this equation connects (4c) and (5c) when $x = l$. Using it, instead of the former $V = 0$, we shall arrive at

$$Z = \frac{(R + Lp)}{m} \cdot \frac{\tan ml + mY/(R + Lp)}{1 - \tan ml.\, mY/(R + Lp)}, \quad . \quad (10c)$$

instead of (8c). Now, just as before, adjust the constants of lines 3 and 4, so that $m_3l_3 = m_4l_4$, and in addition, make $Y_3/Y_4 = s$. Then, supposing each side of the quadrilateral to be a telegraph line, the full conditions of balance by this kind of reduced copies are

$$\left.\begin{aligned} &\frac{R_1l_1}{R_2l_2} = \frac{L_1l_1}{L_2l_2} = \frac{S_2l_2}{S_1l_1} = \frac{K_2l_2}{K_1l_1} = \frac{Y_1}{Y_2} \\ &= \frac{R_3l_3}{R_4l_4} = \frac{L_3l_3}{L_4l_4} = \frac{S_4l_4}{S_3l_3} = \frac{K_4l_4}{K_3l_3} = \frac{Y_3}{Y_4} \end{aligned}\right\} \quad . \quad . \quad (11c)$$

The difference from the former case is that we now have in sides 2 and 4 reduced copies of the terminal apparatus of lines 1 and 3. It will be observed that the equalities in the first line of (11c) make side 2 a reduced copy of side 1, and that those in the second line make side 4 a reduced copy of 3, whilst the equalisation of the two lines of (11c) makes the scale of reduction the same, so that AB_2C is made a reduced copy of AB_1C.

If one of the four sides, say side 3, of the quadrilateral be a telegraph line, we must have at least one another telegraph line, or imitation line, namely, in side 4. But, of course, sides 1 and 2 may be electrical arrangements of a quite different type. Further, notice that only two of the sides, either 1 and 2, or 3 and 4, can be single wires with return through earth, so that if the other two are also to be telegraph lines they must be looped, or double wires. In certain cases precisely the same form of Z as that above used will be valid, but this is quite immaterial as regards balancing by means of a reduced copy.

The balance expressed by equation (3c) is exact—that is, it is independent of the manner of variation of the current. The balance by means of reduced copies is also exact, but is only a special case of the former. But there is always, in addition, the periodic or S.H. balance, when the currents are undulatory. Then merely two conditions are required, to be got by putting $p^2 = -n^2$ in $Z_1Z_4 - Z_2Z_3$, where $n/2\pi$ is the frequency, which will reduce it to the form $a + bp$, in which a and b contain the frequency. Now, $a = 0$ and $b = 0$ specify this peculiar kind of balance, which is, generally speaking, useless. Whilst, however, the balance of AB_1C and AB_2C by making the latter a reduced copy of the former is, when applied to the Christie, only a special case of (3c), it is, in another respect, far more general; for it will be observed that any pair of corresponding points may be joined by the bridge wire, although the result may be an arranagement which is not the Christie.

(To be continued.)

THE PROPOSED ELECTRIC LIGHTING OF THE CITY OF WATERFORD.

The Municipality of Waterford has for some time past found reason to complain of the charges of the local gas company, and they are now determined to discover whether, by means of the electric light, it will not be possible to obtain a far more efficient service at the same cost. In response to our request, Mr. J. W. Howard, the town clerk of Waterford, has courteously furnished us with the statement which we print below. He also sends a map of the city, which we reproduce on next page. It will be seen that the streets are at present lighted by means of 358 gas lamps, at an annual cost of £1,400. Now, in America, it has been found by experience that each 1,200 candle-power arc light displaces on the average six gas lamps, *if placed at the same level*, and the number displaced rises rapidly as the height of the lamp post is increased, until for the so-called "tower" lights, placed at a height of 100ft., no less than 16 gas lamps are superseded. Taking, however, the most unfavourable case, we will assume that each arc is equivalent to only six gas lamps, so that the number of arc lamps required will be about sixty. Now, at Taunton the Corporation has a contract with a local company to supply them with 30 arc lights (just half the number required at Waterford), to burn on an average eight hours per night, at an annual charge of £652. 10s. per annum. If, therefore, the local conditions at Waterford are not more unfavourable than at Taunton (and we know no reason why they should be), it will appear probable that an actual saving would result from the adoption of the electric light. The Town Clerk's statement is as follows:—

"The public lamps in Waterford, within the boundary shown on the map, are in number 358, and are lighted with gas supplied by a private company called the Waterford Gas Company, incorporated under a special Act of Parliament, and having power to open streets, lay mains, &c. Of late years the annual cost of the public lamps has been about £1,400 per annum. The company make a fixed annual net charge of £3. 16s. per lamp.

"The Corporation has long been of opinion that this charge

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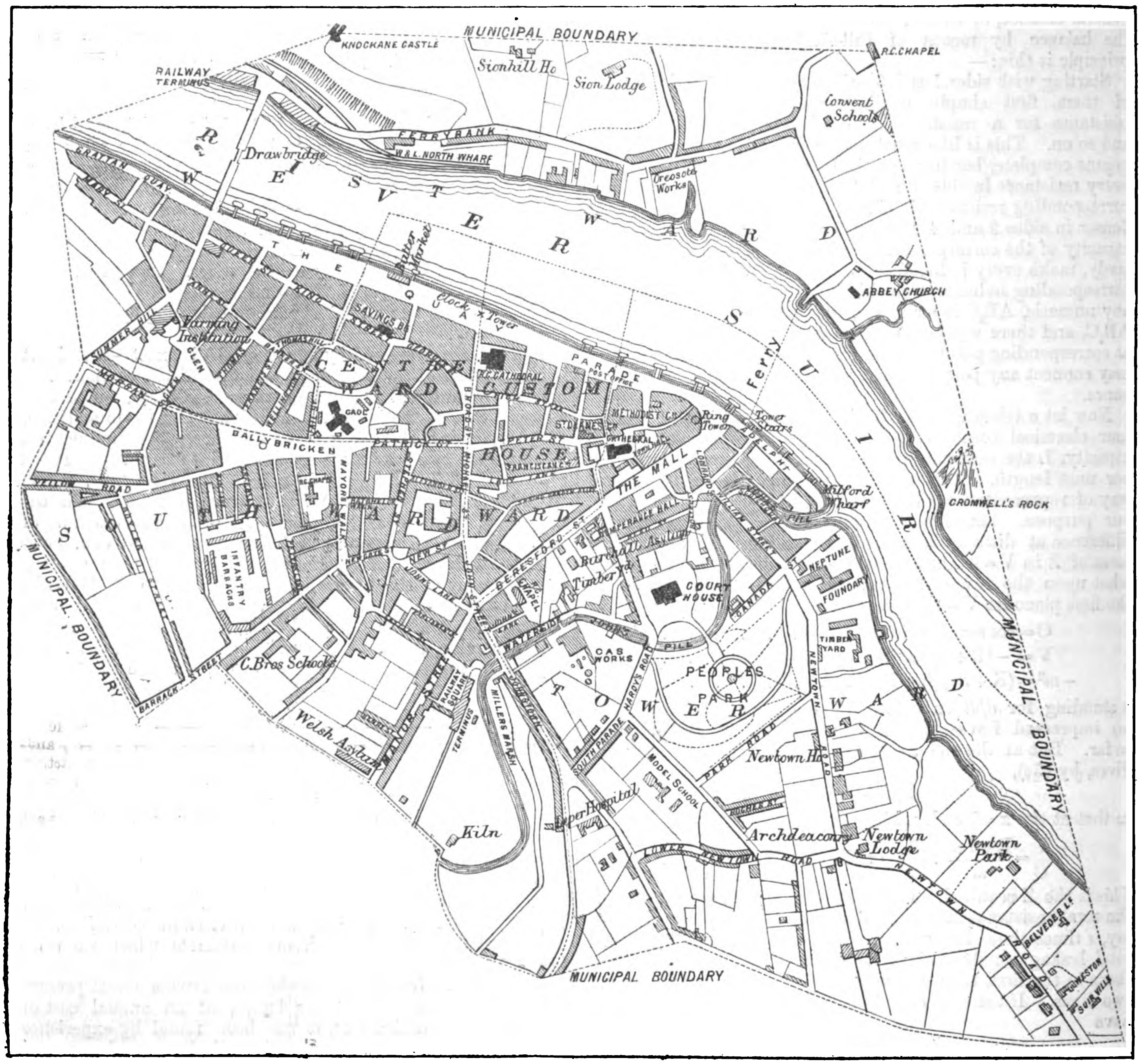
THE PROPOSED LIGHTING OF WATERFORD.—MAP OF THE CITY.



is most exorbitant, and has refused to renew the contract with the company on even reduced fixed prices per annum for each lamp; but they have proposed to take the gas by meter and pay for same per 1,000 cubic feet, fixing one meter on every tenth lamp, and thus averaging the consumption through the city. The company have declined to accept the average system, and require that a meter should be placed *on every lamp*, thus involving an enormous expense to the Corporation in providing meters and adapting the present lamp post to the change.

"The lamp posts, lamps, &c., and all the plant are the property of the Corporation.

"The price (net) charged by the Company to private consumers is 4s. 3d. per 1,000, and this is deemed to be at least 9d. too much.

"Failing to come to terms with the Company the Corporation has resolved to light the city with oil or electricity, and with that view will be glad to receive tenders for supplying the electric light. About fourteen miles of streets must be lighted, and the area comprised within the city boundary is about 530 acres.

"The Harbour Commissioners also light portions of the quays with about sixty gas lamps, and there are three large railway stations, besides numerous public institutions immediately adjoining the borough, all of whom, there is no doubt, will avail themselves of the electric light if it be introduced. The population of Waterford is about 23,000."

THE IMMISCH ELECTRIC MOTOR.

On Saturday last, on the invitation of Messrs. Immisch and Co., a party of mechanical and electrical engineers visited their works at Kentish Town, and witnessed the performance of the Immisch motor under various practical conditions. We have so recently described at length the construction of this motor that at present we shall content ourselves with little more than a bare enumeration of the several applications which were here exhibited. The party received in each case a very full and lucid explanation from Mr. Albion T. Snell, electrician to the company.

The first set to be examined consisted of a plant which had just been completed to the order of an Australian Gold Mining Company, for the purpose of delivering about 10 horse-power to drive stamping machines at a distance of a mile and a-half from the water-side, where power is originally obtained. The dynamo was designed to give 300 volts, with 30 amperes, at 700 revolutions, and the motor runs at 1,000 revolutions. The

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machines are each simply series-wound, but effective regulation has been obtained by an application of the method described by Mr. Kapp in his "Electric Transmission of Energy," p. 178. This method consists in designing the machines so that on plotting the characteristic of the motor, and adding at each point an ordinate representing the total loss of E.M.F., with the given current in the entire circuit we shall obtain the characteristic of the dynamo. This method is therefore applicable to all series motors driven by series-wound dynamos, when the total resistance of the circuit remains a fixed quantity. We were unable on Saturday to carry out a complete test of the regulation attained, because the machines were coupled terminal to terminal, and the 1½ ohm which has been allowed for the resistance of the line was not represented. Under these circumstances the following figures, which show that a regulation within 7 per cent. was actually given, can only be considered highly satisfactory :—

Speed.		Volts.	Amp.	E.H.P.
Dynamo.	Motor.			
680	1,070	155	12	2·5
640	1,000	280	31·5	11·8

The variation in the E.M.F. of the dynamo was effected by means of a variable shunt on the field magnets. Other series of tests gave similar results. The motor was employed to drive a second dynamo, and the load was varied by shunting the field of this machine and varying the resistance of the shunt. This method is very convenient, but it has the disadvantage of rendering it impossible even to estimate the horse-power actually transmitted. Other tests carefully made by Mr. Snell have, however, enabled an efficiency of 90 per cent. to be claimed for the motors and 90 per cent. for the dynamo; the loss in transmission in this case (45 watts) is negligible. The brushes were all fixed throughout the trial, and the entire absence of sparking in all three machines (even, in respect to the third, under the very unceremonious treatment it received) was particularly noticeable. It should be added that the dynamo weighs 17·25cwt., and the motor 6·25cwt., or 70lb. per horse-power.

Among other machines shown we may mention a 5-unit shunt-wound incandescent dynamo, giving at 100 revolutions 108 volts and 48 amperes, and weighing 6cwt.

The party next inspected some tramcars and electric locomotive gearing, constructed for the Electric Traction Syndicate, and driven by Immisch motors. Gearing of several different types was shown running on absorption brakes. For heavy work a sun and planet gearing has been devised, and is intended more especially for employment with separate locomotives. For lighter work a worm and wheel gear running in an oil bath is preferred; this is somewhat similar to that introduced by Mr. Reckenzaun for the same purpose. In each case the motors and dynamos were series wound, and excellent speed regulation was obtained, as before. The practical conditions of electric railway working on a large scale are, however, obviously unsuited to the immediate application of this simple method of regulation, because the loss of E.M.F. in the line must be continuously varying with respect to every machine. It remains to be seen whether these difficulties cannot be overcome.

The visitors next made their way to an adjoining factory, where a Lafitte polychromatic printing press, and also a type-cutting machine, are in daily use, driven by an 8 horse-power motor. This arrangement has been working with unqualified success for the last six months.

Returning to the Immisch Factory the mechanical engineers present were much interested in the performance of Mr. F. J. Rowan's Electric Riveter, a machine for riveting ships' plates *in situ*. The apparatus is slung over the side of the ship, and, being supplied with current from a dynamo by means of two powerful electro-magnets, it readily holds itself in any required position over the rivet to be closed up. The workman then turns a switch, and a small motor, acting by reducing gear upon a cam, draws back the hammer against the pressure of a very powerful spring, which is placed between the magnets. Coming to the top of the cam the spring is liberated, and a very powerful blow is delivered upon the rivet. This action can be repeated at the rate of 150 times a minute, and the tension of the spring can be adjusted with great nicety. The whole apparatus is under the most complete control; but on account of its necessarily considerable weight, although one man can operate it, it requires two men to shift its position. We hope shortly to be able to give some further information, with drawings, of this interesting machine. Now that all large steamers carry their own dynamos, it may be expected that machines of this class, which are capable of materially expediting the work of repairs, will find a large field of usefulness.

THE LAY TORPEDO.

The prospect of spending some hours in an open boat off the coast of Essex could scarcely be said to look particularly inviting when, on Saturday morning last, a party of some forty or fifty individuals assembled on the platform of Liverpool-street Station. Military and naval men predominated, among others present being Lord Charles Beresford, Sir Andrew Clarke (the Inspector-General of Fortifications), Colonel Armstrong, R.E., and the naval and military attachés of various foreign Governments. The expedition was undertaken for the purpose of witnessing the performance of an electrically-governed torpedo devised by Colonel Lay (of the U.S. Army). The experiments were to take place at the mouth of the River Colne.

The Lay torpedo is not altogether a new invention. In 1882 successful experiments were carried out in the Bosphorus, with the result that the weapon has been adopted both by the Turks and by the Russians. Since that period, however, numerous improvements are said to have been effected, and we were to witness the trials of the latest and most perfect type. On reaching Brightlingsea shortly after noon it was discovered that the steam launch which had been ordered round from the Thames and upon which we were to have embarked had been delayed by the fogs, and had not yet made her appearance. It had, however, been arranged that the party were to be taken on board a guard ship which lay about half a mile outside the Brightlingsea Creek. The voyage was made in a fleet of small boats, and on reaching the guard ship the torpedo became visible slung from a cutter which was anchored alongside.

The Lay torpedo consists of a brass cylinder 21ft. long and 18in. in diameter. The head is pointed, and would, on active service, be charged with 150lb. of roburite—one of the new explosives. Three feet from the nose is a gap in the lower surface of about 12 inches, in which a three-bladed screw propeller revolves. The screw is driven at 500 revolutions by a "Tower" spherical engine, of 16 horse-power, which is supplied with power by a charge of compressed carbonic acid gas. A pair of rudders are mounted at the stern, while between them projects a tube about 6in. in length. As the torpedo proceeds on its way an insulated double conductor cable is paid out through this tube, being unwound from a drum placed within. This plan is evidently preferable to that of causing the wire to be dragged along after the weapon.

By means of a current sent through this conductor, four separate and distinct actions are controlled from the firing point. The engines are started and stopped, the steering is effected by means of the twin rudders, the degree of submersion is regulated, and finally the charge is fired. The torpedo ordinarily proceeds at a depth of only an inch or two below the surface; if it is desired to sink deeper, a valve is opened admitting water, and in order to rise again, carbonic acid is admitted on the top of the water, thus blowing it out. It will thus be seen that the operator has, or should have, at all times the most complete control of the weapon. The precise method adopted by the inventor for effecting the four actions, and for adjusting the position of the rudders with accuracy, is not disclosed, but it is easy to understand how it can be done by means of a system of properly adjusted, polarised, and non-polarised switches and relays; but whether success would or would not be attained obviously depends in a matter of this kind upon minute attention to points of detail, and can properly only be determined by experiment. For the firing circuit, of course, high tension fuses operated only by induced currents are employed; but still it scarcely seems satisfactory to complete the firing circuit over the same wires which are used for the manipulation.

Unfortunately, we were not destined upon Saturday to learn from our own observation how far Colonel Lay has actually succeeded in working out these details, although we are assured that perfect success has been attained. Owing to the non-arrival of the steam launch which, as already explained, was to have taken the party further down the river, it was determined—somewhat injudiciously, perhaps—to attempt a run in the Brightlingsea Creek. The result was unfortunate; the tide was low, weeds were plentiful, and although the torpedo started off merrily enough, its career was speedily cut short. What had happened exactly it is difficult to say; but in some way the cable was broken, the engines ceased working, and the experiments were prematurely concluded.

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All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

CONTENTS.

Notes ... 385
Electromagnetic Induction and its Propagation. By Oliver Heaviside. (Continued.) Illustrated ... 390
The Proposed Electric Lighting of the City of Waterford. Illustrated ... 391
The Immisch Electric Motor ... 392
The Lay Torpedo ... 393
UNDERGROUND TELEGRAPHS ... 394
Correspondence ... 395
On the Limiting Distance of Speech by Telephone. By W. H. Preece, F.R.S. Illustrated ... 395
On Reversible Lead Batteries and their Use for Electric Lighting. By D. G. FitzGerald ... 397
On the Application of Alternating Currents to the Determination of the Conductivity of Electrolytes. By T. C. Fitzpatrick. Illustrated ... 400
The Electric Lighting Bill and the Corporations ... 402
Companies' Meetings—
Western and Brazilian Telegraph Company ... 402
Maxim-Weston Electric Co. ... 404
City Notes, &c. ... 406
Companies' Share List ... 406

ANSWER TO CORRESPONDENT.

B. P. S. (Leeds).—*In order to become an Associate of the Society of Telegraph-Engineers it is necessary to obtain from the Secretary (4, The Sanctuary, Westminster, S.W.) a nomination form, whereon you will write your qualifications. The form will have to be signed by a proposer, who must have a personal knowledge of the applicant—who, in fact, becomes sponsor, and is guarantee to the Society that the candidate is a fit and proper person to become a member. The nomination form must also be signed by a seconder and other members or Associates knowing the candidate personally or by repute, these being further guarantees as to fitness. The nomination form so signed is sent to the Secretary, who submits it to the Council. If approved by the Council the nomination is read at an ordinary meeting of the Society, and election takes place at a subsequent meeting. Election should be certain if the nomination is approved by the Council.*

UNDERGROUND TELEGRAPHS.

It appears from the Postmaster-General's answer to a question in the House of Commons on Monday night that the Post Office Telegraph Department has had its attention drawn to the question of placing the telegraph service of the country underground, out of the reach of such catastrophes as that which interrupted telegraphic communications in the South of England for several days last Christmas. That the subject should be considered after that tremendous storm, and the outcry raised at the time, is not surprising; but neither is it surprising that the result of the inquiry is adverse to any considerable change in the direction then recommended. Mr. RAIKES, in replying to Mr. BARRY, stated that the question of placing the Post Office wires underground had been fully gone into, but that "the professional advisers of the Department are opposed to the scheme on the ground of its very great expense." If Mr. RAIKES has been correctly reported, we can express only a qualified approval of his reply, the one satisfactory feature about it being that for the present, at all events, no attempt will be made to coerce the "professional advisers" into an opposite way of thinking.

This is gratifying so far it goes, but we fear that it does not go nearly far enough. Nay, the language employed by the Postmaster-General seems rather to encourage a reopening of the question at no distant date, and may be construed into an invitation to the advocates of heroic remedies to worry the permanent officials. It will be thought that they hold views which he does not share, and that their objection is solely on account of the expense, an objection which he himself would be willing to disregard if only he had command of the necessary funds. If this is the true construction to be placed upon his words—and his recent conflict with at least one permanent official of high standing lends some colour to it—one more example is afforded of the mischievous effects of political exigencies upon administrative functions. It has lately become the fashion for the political head of a department to make capital out of real or supposed difference between himself and his permanent subordinates. The worst of it is, he is sometimes called upon to act up to his words, and the matter is then finally settled, not on its merits, but at the dictation of a hungry or fanatical faction.

We say hungry or fanatical because, at the bottom of such agitations as those which are constantly demanding increased expenditure or reduced tariffs (which generally amount to the same thing), there is always a selfish as well as a doctrinaire spirit actively at work. A few pedantic reformers are in the forefront to recommend changes, because their occupation would be gone if there were no changes to recommend; and these are backed up by a following whose only aim is to derive some pickings from the scramble which follows success. This is how it works in Parliament, and in the press the motive is no less selfish. Witness the chorus of articles a couple of months ago demanding the immediate laying down of all telegraph wires underground, because forsooth the newspapers were deprived of their usual quota of news by reason of a snowstorm of unusual magnitude. Their demands were followed up by "correspondents" abusing the Government for not putting the wires out of harm's way in the easiest manner possible. These complaints as soon as Parliament met found a willing echo there; and if we escape an agitation on this basis, especially after Mr. RAIKES's latest deliverance, we may consider ourselves exceedingly lucky.

For, be it remembered, to the genuine parliamentary reformer the "expense" of his proposals is rather a recommendation than otherwise. If the difficulties, for example, of laying and working wires underground were merely electrical, we might rest assured that no more would be heard of underground telegraph wires; but precisely because a vast sum of money would have to be spent if the scheme were carried out we hear nothing at all about the practical difficulties. When at last those practical difficulties have to be considered, they will be met by the recommendation to spend more money to overcome them. Cost is of small moment, we are told, where the public welfare is concerned, just as if the public had not to pay for the whistle which these reformers so dexterously play upon. And matters

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are made worse by the fact that these are the very men who, in and out of season, declaim against national expenditure. One evening they will enthusiastically advocate the spending of a large sum of money, and the next they are seen cutting down the Estimates, which have necessarily swollen in proportion. At this very moment there is widespread, and perhaps well founded, discontent in the Postal Telegraph Service in consequence of the slowness of the Treasury in adequately recognising the immense additional work thrown upon the *employés* by the luxury of sixpenny telegrams. We do not observe that the foremost promoters of that costly experiment are at all forward in paying the people for it who have been instrumental in carrying it out at their bidding. There is no prestige to be earned by liberality of that sort.

To readers of this journal little need be said of the proposition itself. We have spoken of it on a former occasion, and summed up our remarks by the statement that to put our telegraph wires underground would not only involve a vast outlay of money, but would materially diminish the speed of working all the year round, merely for the sake of escaping a breakdown about once in every tenth year. Continental nations have reasons of their own, chiefly military, for safeguarding their telegraph lines in that way; but these reasons have no applicability to this country, and never can. For ought we know to the contrary, our military authorities have taken what precautions would be needful for time of war; but be that as it may, whatever harm may come to us from a hostile demonstration, our inland telegraph system will not be the chief, or, indeed, a very great sufferer. Of alternative routes we have already enough and to spare. Every line, telegraphically speaking, is an alternative route, and certainly for military purposes, if not for commercial requirements, one route is almost as good as another. Nevertheless, there are certain points between which, both for strategical and commercial reasons, it might be desirable that permanent lines should be gradually established underground. But this is a very different thing to revolutionising the whole, or indeed any portion of the existing overhead system, except within the precincts of towns, where such wires are both a danger and a nuisance. If the present Postmaster-General would bestow some attention upon these latter, and in his capacity as legislator insist that the good example set by the Post Office shall be followed by the Telephone Companies, he would be doing a very popular thing, and one in which he would be supported, if needful, even against his "professional advisers."

CORRESPONDENCE.

"MAXWELL'S THEORY OF ELECTRICITY."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps the gentleman who wrote the article headed "Maxwell's Theory of Electricity" will kindly enlighten me on the following:—He says (*Electrician*, Feb. 11, p. 312) "The potential energy of each pole is in reality due to the kinetic energy of the molecular whirls, and the energy resides not in the poles themselves but in the interposing medium." Now, what I understood on reading the article was that the whirls are due to the lines of force, which again are due to the poles; therefore, the energy of the whirls is due to the strength of the pole, and the lines of force, of course, depend on the strength of pole. I maintain that the potential energy is due to that energy which was expended in magnetising the magnet, and that the potential energy of the poles cannot be due to the kinetic energy of the whirls, for the very reason that, according to the article, the pole sets up the whirls. Trusting that you will be good enough to insert this in your next.—Yours, &c.,

A STUDENT.

ON THE LIMITING DISTANCE OF SPEECH BY TELEPHONE.*

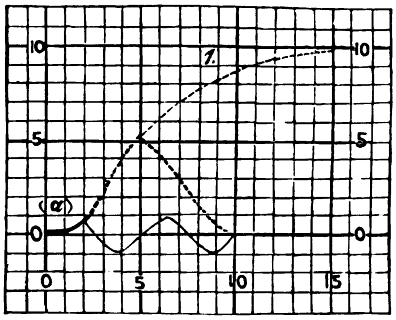
BY WILLIAM HENRY PREECE, F.R.S.

The law that determines the distance to which speaking by telephone on land lines is possible is just the same as that which determines the number of currents which can be transmitted through a submarine cable in a second. The experimental evidence upon which this law is based was carried out in 1853 by Mr. Latimer Clark (whose assistant I then was). The experiments were made by me in the presence of Faraday; many were his own; he made them the subject of a Friday evening discourse at the Royal Institution, January 20, 1854, and they are published in his "Researches" (Vol. 3, p. 508). They received full mathematical development by Sir William Thomson in 1855 (*Proc.* R.S., May 24th, 1855), who determined the law, the accuracy of which was proved by Fleeming Jenkin and by Cromwell Varley, and the 110,000 miles of cable that now lie at the bottom of the ocean afford a constant proof in their daily working.

Hockin reduced Thomson's law to the following series:—

$$x = C\left(1 - 2\left\{\left(\tfrac{3}{4}\right)^{\frac{t}{a}} - \left(\tfrac{3}{4}\right)^{\frac{4t}{a}} + \left(\tfrac{3}{4}\right)^{\frac{9t}{a}} - \left(\tfrac{3}{4}\right)^{\frac{16}{a}} + \&c.\right\}\right),$$

which allows it to be expressed by the following curve (1):—



Now a is a time constant dependent on the conditions of the circuit, invariable for the same uniform circuit, but differing for different circuits. It represents the time that elapses from the instant contact is made at the sending end to the instant that the current begins to appear at the receiving end. It is given by the following equation:—

$$a = B\,krl^2,$$

B being a constant dependent principally on the units used; k the inductive capacity per unit length (mile or knot); r the resistance per unit length, and l the length in miles or knots.

a, therefore, limits the number of vibrations per second that can be sent through any circuit. If a be 0·196 second, as it was in the French Atlantic cable of 1869,† 2,584 knots long, them it is impossible to send 5·1 currents per second through that cable; but it would be possible to send 5 or 2½ complete reversals per second. Moreover, as the number of reversals varies inversely with the square of the length, it shows that such a cable if of 100 miles length would allow 1,562 reversals to pass through it. It is necessary to remark that these expressions involve no mention of E.M.F., or of current, and therefore the number of reversals which can be produced at the end of a wire is quite independent of the impressed E.M.F., and therefore of the strength of the current. But the number of the reversals is dependent upon the sensitiveness of the apparatus used to receive the currents, for if we use an instrument which will respond to a current indicated by the full line, we get two currents per second; and if we use an instrument which will respond only to the dotted line, we get only one current in two seconds, which is about the current used with delicate relays in this country. This is why such discordant results are obtained by different observers who attempt to measure the velocity of currents of electricity. It is also why the telephone is such an admirable instrument for research—for it is sensitive to the least increment or decrement of current.

Before proceeding with this inquiry it was necessary to determine very accurately the inductive capacity of overhead and underground wires. This was done with great care on very dry days in different parts of the country by means of a Thomson mirror galvanometer and a standard condenser.

The results come out as follows:—

	Capacity per mile microfarads.	Resistance per mile B. A. ohms.
No. 7½ iron wire	0·0168	12·0
No. 12½ copper wire	0·0124	5·7
Gutta percha-covered wire in iron pipes ...	0·2500	23·0
Gutta percha-covered wire in cables	0·2900	10·25

* Read at the Royal Society, March 3rd, 1887.

† Fleeming Jenkin, "Electricity and Magnetism," p. 331.

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TABLE SHOWING THE SPEED OF CURRENT THROUGH WIRES.

Wire.	Route.	Length in miles.	Total resistance × Total capacity.	Speed of current in seconds.	Telephonic notes.
Nos. 142 and 144, Denham and Atherstone	New West Coast... Open .... Covered	90 2·5	2247·0	0·0007 calculated.	Gower-Bell Telephone. Speaking good.
London and Denham	Underground	21	2963·5	0·0009 calculated.	Ditto ditto.
Nos. 142 and 144, Denham and Stafford	New West Coast... Open .... Covered	119 5	4715·7	0·0015 calculated.	Gower-Bell Telephone. Speaking fairly good.
South Wales	.... Open .... Covered	79 1·25	5680·0	0·0016 calculated.	Gower-Bell Telephones. Working satisfactorily.
Newcastle Telephone system, Warkworth to Stockton P.O.	*Viâ* Newcastle, Sunderland, and West Hartlepool Open ...... Covered ..	63·831 12·039	5817·6	0·0016 calculated.	Gower-Bell Telephones. Five intermediate electro-magnets of 1000 ohms resistance, in derived circuit. Speaking satisfactory.
Nos. 142 and 144, London and Towcester	New West Coast... Open .... Covered	50 21	7341·3	0·00234 calculated.	Gower-Bell Telephone. Speaking weak, but just able to hold a conversation.
Nos. 142 and 144, Denham and Nantwich	New West Coast... Open .... Covered	146 7	7612·1	0·0034 calculated.	Gower-Bell Telephone. Speaking weak, but just able to carry on a conversation.
London to Denham (with additional loop between Denham and Hanwell) ...	Underground	39	10221·0	0·0032 calculated.	Gower-Bell Telephone. Speaking good, but approaching the point of difficulty.
Nos. 142 and 144, Denham to Warrington	New West Coast ... Open .... Covered	172 8	10399·16	0·0038 calculated.	Only just able to speak. Impossible to carry on conversation.
Nos. 142 and 144, London to Atherstone	Ditto ... Open .... Covered	90 23·5	12511·2	0·004 calculated.	Only just possible to speak.
New Irish Cable	Cable ...... Open .... Covered	25 62·9	12587·4	0·00412 observed.	Berliner's Telephone. Only just able to talk.
Newcastle district	.... Open .... Covered	30 30	12640·0	0·00412 calculated.	Requires very good telephones and very good voices.
Copper. London to Nevin (land lines for the new Irish cable)	*Viâ* Worcester and Shrewsbury Open .... Covered	251·18 18·5	15771·5	*0·0035 observed.	Berliner's Telephone. Some voices good.
No. 11, London Stock Exchange to Liverpool Stock Exchange (Iron wire, No. 8 gauge)	*Viâ* London and N.W. Railway ... Open .. .. Covered	199·014 7·243	16417·8	0·005 observed.	Telephone not tried.

N.B.—The speed is calculated from the formula $t = 32 \times 10^{-8}KR$. * The constant for copper is 22×10^{-8}.

The capacity can be calculated from the following formula (also due to Sir William Thomson):—

$$K = \frac{l}{2 \log (4\,h/d)},$$

where d is the diameter of the wire and h the height above the ground. Taking h at 500cm., and d at 0·243cm., the capacity comes out for 12½ wire at 0·0113 instead of 0·0124 microfarad per mile. The cause of this difference is referred to further on.

It then became necessary to determine the speed of the current through wires of different lengths, resistances, and capacities.

A multiplex distributor—such as we are now using in the Post Office—enables this to be done with great accuracy. At each station a circle is broken up into 162 sections, and an arm in connection with the line wire carrying a brush sweeps over these sections and makes contact. This arm can be made to rotate at any speed. If it makes three revolutions per second it will make the duration of each contact $\frac{1}{486}$th of a second. Now the two distributors are kept running in absolute synchronism, so that the brush at each station always rests simultaneously on corresponding sections. The sections at one station can be placed in contact with the battery, and those at the other station with a galvanometer or other sensitive apparatus. If the current traversed the wire instantaneously then it would appear on the same section at the same time on the galvanometer; but the current is always retarded, and the amount of retardation or the value of a can be measured and the curve of arrival and cessation drawn by watching the indications of the galvanometer on each succeeding section.

The above table summarises a large number of experiments that have been made in different parts of the country, and on different lines, to determine by observation the connection that exists between speed of current, distance spoken through, resistance, and capacity. The maximum current, or the crest of the wave, was observed. This was equivalent to 0·003 ampere.

It will be seen that the limiting distance through which it is possible to speak varies inversely with the speed of the current, and that the speed of the current varies inversely with the product of the total resistance and the total capacity of the circuit. Hence we can say that the number of reversals that it is possible to send through any circuit varies inversely with the product of the total resistance (R) and the total capacity (K), or the limiting distance

$$S = KR \times \text{constant}. \quad . \quad . \quad . \quad . \quad . \quad (1)$$

This is only another form of Thomson's law for $K = lk$, and $R = lr$, and $\therefore S = krl^2 \times$ constant.

It is seen that when the speed of the working current was

0·001′ speaking was perfect.	0·003′ speaking was fair.
0·002′ speaking was good.	0·004′ speaking was difficult.

If we put equation (1) into this form,

$$A = krx^2, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and give to A the following values:—

Copper (overhead)	15,000
Cables and underground	12,000
Iron (overhead)	10,000

we can find the limiting distance we can speak with any wire; for

$$x^2 = A/kr.$$

Take copper, whose constant is 15,000, and a wire whose resistance is 1ω per mile, and capacity 0·0124 per mile, then—

$$x^2 = \frac{15000}{0·0124}, \qquad x = 1100,$$

which is the limit of speaking upon such a wire.

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The wire used between Paris and Brussels has a resistance of 2·4 ohms and a capacity of about 0·012 microfarad per kilometre, and as that distance is only about 200 miles the speaking must be excellent. Moreover, there is reason to believe, from the difference between observation and calculation, that the static capacity on Continental and American lines is less than that of English lines, owing to the use of earth wires on all poles in England, and therefore the distance would be greater.

Take an Atlantic cable—

$$x^2 = \frac{12000}{3 \times 0{\cdot}43} \qquad x = 96.$$

Now I had found in 1878* that it was just possible to speak through 100 miles of such a cable—a very close agreement.

Moreover, by the law of squares, 100 miles of an Atlantic cable ought to transmit 1,562 reversals, if 2,584 miles transmit $2\frac{1}{2}$, and this is probably the average number of sonorous vibrations imparted by the human voice, when hearing by telephone begins to get difficult by the loss of the higher partials and overtones.

There is another interesting consequence of Thomson's law which comes out of these experiments, and that is, whether the line be a single wire completed by the earth, or a double wire making a metallic circuit, the rate of speed between the two ends is exactly the same, and therefore the distance we can speak through is just the same whether we use a single or double wire circuit. This is owing to the fact that though in the latter case we double the total resistance, we halve the total capacity, and therefore the product remains the same.

The difference between copper and iron is clearly due to self-induction, or to the electromagnetic inertia of the latter, and the difference between copper overground and copper underground is due to the facility that the leakage of insulators offers to the rapid discharge to earth at innumerable points, of the static charge, which in gutta percha-covered wire can find an exit only at the ends.

It is also evident that there is no difficulty in working telephones through underground wires, even though they attain 50 miles in length, and in fact it would be better to work underground with proper copper wire from London to Brighton, than to use iron wires along the railway telegraph poles, owing to the absence of external disturbances in the former case.

The limit of working of different insulated wires is easily obtained by equation (2), and the following table gives that information for different gutta percha-covered wires:—

No.	*k.*	*r.*	Limit of speech.
$\frac{20}{11}$	0·270 mf.	45·00 ohms.	32 miles.
$\frac{18}{7\frac{1}{2}}$	0 250 „	23 00 „	46 „
$\frac{16}{4}$	0·240 „	13·00 „	62 „
$\frac{107\text{lbs.}}{150\text{lbs.}}$	0 290 „	10·25 „	64 „

N.B.—The top number indicates the gauge of wire, and the lower number that of the gutta percha.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The ordinary general meeting of this Society was held at the Institute of Civil Engineers, George-street, Westminster, yesterday (Thursday). The President, Sir Charles Bright, occupied the chair.

The SECRETARY having read the minutes of the previous meeting, which were confirmed and signed as correct,

The PRESIDENT announced that there had been, during the last fortnight, several contributions made to the Society's library, and proposed a vote of thanks to the donors, which was cordially agreed to.

Mr. DESMOND G. FITZGERALD then read the following paper (the discussion upon which was opened by Dr. J. H. Gladstone and Mr. W. H. Preece, and will appear in our next issue):—

ON REVERSIBLE LEAD BATTERIES AND THEIR USE FOR ELECTRIC LIGHTING.

When the cheap production of electrical power by means of the dynamo machine was first realised as a *fait accompli*, there were many who naturally, but somewhat rashly, assumed that cheap electrical power would immediately become generally available for electric lighting in private dwellings and for many other applications on a small scale. These anticipations, we all know, were doomed to disappointment—most of us have found it impracticable to introduce electrical power into the household; and the privilege of making use of the most beautiful, cleanly, and hygienic means of artificial lighting has hitherto been denied to us. It may be interesting at the present moment—when the lead storage battery is claiming renewed attention—to glance briefly at the grounds for the sanguine anticipations which were formed soon after Werdermann brought the machine of Gramme into this country, to recall some of the main causes of their non-realisation, to examine critically the accepted views as to the chemical and electro-chemical reactions involved in the working of reversible lead batteries, to estimate the probable extent to which such batteries may be improved, or the room there may be for improvement, and, lastly, to consider, at least in its *primâ facie* aspect, the question as to the practicability of carrying the original anticipations into effect by means of an improved form of reversible lead battery.

It is admitted by high engineering authority that, with steam engines of improved construction and of not less than 300 horse-power nominal, it is quite practicable to obtain a horse-power hour mechanical by the combustion of two pounds avoirdupois of good coal. Allowing 20s. per ton for such coal, the cost of the fuel to develop this quantity of energy would be considerably under one farthing (·214d.). Putting the commercial efficiency of the dynamo machine roughly at 70 per cent., the cost of the horse-power hour electrical would be less than one third of a penny (·306d.). Taking everything into account, Sir W. Siemens, in 188?, could not estimate the cost of production, in London, of the H.-P. hour electrical at a higher figure than nine-tenths of a penny (·895d.). There are incandescent lamps that will yield a candle-power for every $2\frac{1}{2}$ watts expended; and, taking the horse-power electrical as 736 watts, it would thus be equivalent to the illuminating power of 294 standard candles. The price in London of the gas to produce this illumination for one hour may be estimated at about $2\frac{1}{2}$d.; and in London gas is cheaper than in most other localities. It was natural that figures analogous to these should arouse sanguine anticipations in the electrical engineer—

And duller should we be than the fat weed
That rots itself in ease on Lethe's wharf
Were we not moved at this.

But when, in this country and elsewhere, the requirements for domestic electric lighting came to be practically considered, it was found on the one hand that—in spite of the capabilities of the individual celebrated amongst our Parisian *confrères* as *le jardinier de M. Preece*—no private individual would, as a rule, willingly incur the prime outlay, trouble, and comparative expense of a small steam or gas engine and a dynamo machine; and, on the other hand, that the cost and difficulty of laying down leads to supply even a populous district with electrical power from a central station was a very serious consideration. After 1882, when electric lighting was made a stalking-horse by the worst sort of company promoter, it was clearly seen that this mode of supply, involving an investment of capital even larger than that which had gradually been made in gas, would be out of the question for many years to come. I have no doubt that it will ultimately be adopted to a large extent—but this will not be, I think, in the lifetime of those of us who have passed the middle age; nor do I think that the distribution of electrical power from central stations will at any period altogether supersede the method of distribution, by means of elements in which electrical energy has been stored, to which I shall presently advert.

The electro-chemical means at present available for the storage of electrical energy cannot, either from a scientific or a practical point of view, be regarded as perfect; and it seems certain that they will be considerably improved in future years. The trite saying that the storage battery is still in its infancy is perhaps not inapplicable; but it would be a mistake to ignore the fact that important improvements have been made in this apparatus since (seven years ago) the cell of Gaston Planté was first modified by Camille Faure. Under the headings of "Storage Capacity," and "Weight per Horse-power-hour," I have jotted down from my note book, in tabular form, some figures, subject to correction and amplification, which in some measure illustrate this improvement, although there are other points of equal importance which require to be taken into account. The "lithanode" mentioned in these tables was the subject of a paper which I read at the British Association Meeting at Birmingham, and which will be found in *The Electrician* of September 10, last year. It is peroxide of lead (with more or less sulphate of the metal) in a coherent and highly conductive form, having generally a specific gravity between 7·5 and 7·9. I shall have occasion again to refer to this material presently.

In Table I. I have taken the liberty of placing a note of interrogation after the values, relating to the storage capacity of the plates formerly manufactured by the Electrical Power Storage Company, taken from the paper read by my friend and old pupil, Mr. F. G. Howard, in June, 1885, at a meeting of Students at the Institute of Civil Engineers. No doubt Mr. Howard referred to the total storage capacity, instead of the useful capacity of these plates; but even in this case the value given would seem to be much too high. Certainly, the plates now issued by the Electrical Power Storage Company are at least equal to those manufactured by them two years ago; and at the present moment the useful storage capacity claimed by them per lb. of battery is, I believe, 3 ampere-hours on a rough average. In the smaller cells this value may be surpassed—in the larger it is scarcely attained. The present "thin-plate" Electrical Power Storage cells have a capacity of 2·8 ampere-hours per lb. of battery. In practice, as, for instance, at the Colonial and Indian Exhibition, this value, we know, is not always even approached. Now, taking the high value of 3 ampere-hours per lb. of battery, the horse-power cell would weigh 129lb. But, according to the values I have called into question, 41lb. of lead in the battery would

* *Phil. Mag.*, April, 1878.

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TABLE I.—*Storage Capacity of various Secondary Cells.*

Name of Cell.	Per lb. of Pb.		Per kilo. of Pb.		Authority.
	Foot-lbs.	Watt hours.	Kilogram-metres.	Watt hours.	
Planté	12,000	4·52	3,664	10	—
Faure	18,000	6·78	5,495	15	—
E.P.S. L plates.	48,000(?)	18·09(?)	14,600(?)	39·8(?)	Howard.
„ R „	36,080	13·6	11,010	30	(?) Hospitalier.
„ S nominal 22lb. cell	31,800	12	9,540	26	FitzGerald.
Elwell-Parker (old form)...	6,633	2·5	2,018	5·5	Prospectus.
Lithanode battery (old form)	39,798	15	12 110	33	FitzGerald.
Lithanode battery "Union" cell	47,170	17·8	14,671	39·16	G. Forbes.

TABLE II.—*Weight per horse-power-hour Capacity of Various Secondary Batteries.*

Name of Battery.	Elements only		Cell complete.		Authority.
	Lbs.	Kilos.	Lbs.	Kilos.	
Planté	...	...	396	180	Reynier.
Faure	...	...	88	40	Faure.
	...	...	165	75	Sir W. Thomson.
„ (old model	...	...	198	90	Reynier.
„ (new model)	...	...	134	61	
E.P.S. L plates	...	...	133	60·4	Prospectus.
	...	...	110	50	Reckenzaun.
„ S „	66	30	135	61·3	FitzGerald.
Reynier — Zinc posve....	50·6	23	117·5	53·4	R. Tamine.
Reynier — Planté form .	105	47·6	...	...	*Idem.*
Lithanode battery...... (old form)	42	19·1	76	34·5	FitzGerald.
Lithanode battery...... "Union" cell	42	19	70	31·5	G. Forbes.

suffice to produce the horse-power-hour; and this lead would constitute only one-third of the total weight of the battery—a ratio which is far too small, and requires to be increased to at least one-half.

A high ratio of stored energy to weight is not always the most important consideration in a reversible lead battery; and the few data I have collected in tabular form would have been of greater interest if I had specified in each case the *rate of discharge*, since it is well known that the useful capacity becomes diminished as this value is increased. I will to some extent remedy the omission by stating, in regard to the lithanode battery, that when the rate of discharge is about ·446 ampere per lb. of plates, or ·257 ampere per lb. of battery, the useful capacity may be as high as 9·32 ampere-hours per lb. of plates, or 5·3 ampere-hours per lb. of battery. But, when the rate of discharge reaches ·64 ampere per lb. of plates, or ·36 ampere per lb. of battery, then the useful capacity falls to 8·6 ampere-hours per lb. of plates, or 4·8 ampere-hours per lb. of battery. These results have already been far surpassed in the laboratory; but they are probably the maxima hitherto obtained on a practical scale.

UNION CELL.

Rate of Discharge.		Capacity.	
Amperes per lb. of		Ampere Hours per lb.	
Plate.	Cell.	Plate.	Cell.
·68	·41	9·2	5·5
·88	·53	7·1	4·3
1·2	·72	6·2	3·7
1·5	·9	5·5	3·3

Whatever may be said of the lead storage battery itself, it is quite certain, I think, that our electro-chemical knowledge in relation to it is "in its infancy." We should be thankful even for small mercies in this direction, for very few electricians or electro-chemists have given any real attention to the matter, which is one of vital importance to progress. But we should be specially grateful to Dr. J. H. Gladstone and to the late Mr. Alfred Tribe, who gave a great deal of careful labour to "The Chemistry of the Secondary Batteries of Planté and Faure."* I am glad to say this before criticising, to the best of my ability, some of their conclusions from which I venture to differ—or to imagine that I differ.

In the first place there is a little matter—perhaps a *lapsus*—of no great importance perhaps in itself, but which seems to me of importance by reason of the detestation in which I hold anything in the form of "white sulphate" —non-conducting sulphate—in the negative element of a lead storage cell. In their little work, under the above-mentioned title, Messrs. Gladstone and Tribe propound the following question and answer: "In a Planté or Faure battery, the mass of peroxide which is in contact with the (negative metallic lead plate expends its energy slowly in local action. How comes it to pass that if the same mass of peroxide be brought into connection, through the first lead plate, with another lead plate at a distance (in the same electrolyte) it expends its energy, through the greater length of sulphuric acid, in a tenth or a hundredth part of the time? The answer . . . is doubtless to be found in the formation of the insoluble sulphate of lead, which clogs up the interstices of the peroxide, and, after a while, forms an almost impermeable coating of high resistance between it and the first metallic plate." Now it appears to me that this suggested explanation involves a misconception as to the conditions which are favourable to the passage of the local current, of which the direction is from the metallic support to the peroxide through the electrolyte and from the peroxide to the metallic support by simple conductive contact. Not that the resistance (electrolytic) between the supporting plate and its peroxide is *common* both to the local circuit and to the main circuit; for there must be a simple conductive contact between the plate and the peroxide at one or more points (otherwise the detached layer of peroxide would become inactive, and there would be no current in either circuit), and the main current would pass wholly through this contact—as, indeed, would the local current in its passage from the peroxide to the support. But it is evident that the local current, under the given electromotive force, will be inversely as the sum of the resistances in its circuit, and that one of these resistances—that which opposes its passage from the peroxide to the support—must be small (since otherwise the main current would be impeded). The remaining resistance in the local circuit—that which opposes the passage of the local current from the lead support to the peroxide *through the electrolyte*—must evidently be very considerable in order to comply with the conditions under which the current in the main circuit may be ten or a hundred times greater than that in the local circuit. In my view, the electrolytic resistance in the local circuit would be diminished instead of augmented by interposing even an almost impermeable (but more or less moist) coating of sulphate of lead between the peroxide and its support, excepting at one or more points where the peroxide and the lead would be in perfect contact. To maintain perfect unbroken contact everywhere between the layer of peroxide and the lead-supporting plate would, I think, be the best means of diminishing local action, by augmenting the electrolytic resistance in the local circuit. And this, in substance, was the burden of the paper read by Messrs. Drake and Gorham at the British Association last year.* The clogging up of the *interstices* in the peroxide might, I am ready to admit, be beneficial, provided this unbroken contact were maintained. It may be observed, however, that the suggested explanation appears to be further disproved by the figures given by the authors of the work referred to. During the first two hours, when the quantity of sulphate formed is a minimum, the quantity of peroxide reduced by local action is only 3·6 per cent. per hour. In the next hour, when the quantity of sulphate must have augmented, the percentage of peroxide reduced is shown to be nearly 8; and in the following hour it rises to about 10.

Passing to a matter of more general importance, the equation given by the writers I have named as applicable to the batteries of Planté and of Faure—and presumably also to all lead secondary batteries with the same electrolyte—is substantially as follows:—

$$PbO_2 + 2H_2SO_4 + Pb = \underbrace{PbO + H_2SO_4} + PbSO_4 + H_2O.$$

The compounds bracketed together react, however, upon each other, so that the final result may be expressed by

$$PbO_2 + 2H_2SO_4 + Pb = 2PbSO_4 + 2H_2O;$$

the final result being sulphate of lead on both plates.

This equation is very simple, and has been generally accepted as entirely satisfactory. As an expression merely of the chemical results observed, after a certain percentage of the peroxide has become reduced, it is, perhaps, unassailable. As an electro-chemical equation, applicable during the whole period of the discharge of a lead secondary battery with the given electrolyte, it is impossible, I think, to accept it. I will endeavour to lay before you the difficulties I have found in the way of its acceptance.

But in the first place it will be expedient to consider whether there has been any intention of putting forward or accepting this formula as an electro-chemical equation, expressing the reactions on which the efficiency of the battery is dependent. Has there actually been any assumption that the whole of the peroxide is, or may be, converted into sulphate of lead? that a large proportion of isolated sulphate of lead, "white sulphate," is necessarily produced in discharging the battery? that the reduction of the peroxide takes place, not in two or more stages, but continuously? and that the electromotive force of the battery is independent of the quantity of sulphate which has been produced from the peroxide? Because, if not, I might be setting up imaginary antagonists and incurring unnecessary trouble in endeavouring to overcome them.

The authors of the work already referred to make use of the expression given above:—"The final result being sulphate of lead on both plates." Dr. Gladstone, moreover, has explained that, "When we stated that sulphate of lead is finally the only product of the discharge, we were referring to the disappearance of any peroxide, and did not mean to imply that in actual practice the whole of the spongy lead is usually converted into sulphate." Mr. Tribe, in *The Electrician* of July 10, 1885, wrote that "One of the conclusions was that both the peroxide of the negative plate and the finely-divided lead of the positive were converted into lead sulphate during discharge." Mr. George F. Barker, in his paper read at the Montreal meeting of the

* Their work, under this title, is published by Macmillan.

* "On the Treatment of Secondary Batteries."

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American Association for the Advancement of Science, says: "My experiments with the Faure battery confirm entirely those of Gladstone and Tribe as to the formation of lead sulphate." "On examining the plates, lead sulphate formed the entire coating upon both of them." Mr. C. T. Kingzett states that "as fast as the monoxide of lead, produced by reduction at the negative pole during discharge, forms, it is converted into sulphate. Upon complete discharge then there remain two supports of lead coated with sulphate of lead." And Prof. Oliver Lodge says: "The use of peroxide alone (without any support of lead) looks hopeful; but, when the cell is discharged and the peroxide reduced, the plate will no longer be a conductor—and it does not appear probable that such a cell could ever be charged up again." This conclusion, I may here state, is emphatically disproved by the "lithanode" battery plates now before you, most of which have been charged and discharged—down to the potential of 1·8 volt—a great number of times—without losing their conductivity or exhibiting the smallest patch of "white sulphate."

Mr. G. F. Barker further observes that, "Obviously, so long as any peroxide is present, the electromotive force is constant." The same experimenter also makes the following very suggestive note, showing that one at least of his cells had been, apparently accidentally, worked upon an improved system. He says:—"In one of my Planté cells, the peroxide is beautifully crystalline and very hard. Not a trace of (free) sulphate has been formed in it, apparently, though it has been in use for six months, and has been frequently charged and discharged during that time."

On the other hand, Messrs. Gladstone and Tribe state (*loc. sit.* p. 32), in relation to the negative plate:—"At the conclusion of the action we have always found more or less of the substance unaltered. Thus, as one instance, after a discharge lasting five days, and approximately complete, we found that only 68 per cent. of the deposit was lead sulphate." And Mr. J. Swinburne (in *The Electrician* of July 10, 1885) makes an important observation in the same direction. He says:—"The appearance of the coating of an ordinary discharged peroxide plate does not prove the absence of sulphate, for only a very small proportion can be sulphate. Some years ago, when I made a large number of experiments on batteries, I found that in no case more than 6 or 7 per cent. of the coating is used, even when the cell is completely run down. The expansion of the peroxide of lead in becoming sulphate perhaps blocks the coating up."

Let me at once observe that if Mr. Barker were right in stating that the E.M.F. is constant so long as any peroxide is present I should have no difficulty in accepting the above-mentioned formula as the electro-chemical equation applicable to lead secondary batteries. But, like Mr. Swinburne, I have found that long before the whole of the peroxide is exhausted the E.M.F. has fallen practically to zero. If the formula be true, as the electro-chemical equation of the battery, why should there be any fall in the electromotive force before the peroxide is exhausted? Is it because the peroxide becomes "blocked up" or clogged, or so diluted by the inert material, that the support becomes rapidly "polarised" by hydrogen? If so, the formula may be true. But on open circuit, when there can be no polarisation, and with a strip of solid peroxide without support, we should, if the formula be true, obtain the full E.M.F. corresponding to the nature of the chemical reaction indicated by it. We should expect this so long as any peroxide remained—certainly when only 25 per cent. of the quantity originally present had been consumed.

For, a "true battery equation" is of course independent of the resistance of the circuit, and indicates a definite E.M.F. Conversely, if the E.M.F. alters—temperature and certain other conditions remaining the same—we know that the given battery equation no longer applies, that the original chemical reaction has given place to or has become complicated by another chemical reaction.

I take two strips of platinum, to be used as negative elements with a positive of spongy lead in an electrolyte of dilute sulphuric acid. One platinum strip (A) I coat with a paste of electrolytic peroxide of lead; the second strip (B) I coat with a paste composed of one part of electrolytic peroxide of lead and one and one-third part of sulphate of lead (equivalent weights, roughly), mixed together with water. The couples are circuited, consecutively, through 60,000 ohms and a reflecting galvanometer of high resistance. The A couple, as soon as the negative becomes moistened by the electrolyte, gives a steady deflection of 130 divisions corresponding to an E.M.F. of about two volts. I short-circuit this couple for 30 seconds, or for ten times this period—of course the deflection falls to zero; but, when the short-circuit is broken, the spot of light moves back to 130 within a few seconds. The B couple gives 128 divisions, falling steadily within a few minutes to 72 divisions, corresponding to rather more than one volt (this through a resistance of over 60,000 ohms). I short-circuit this couple for one second; on breaking the short circuit the deflection is 20 divisions, becoming in five minutes 67 divisions. A strip of plain platinum gave a deflection of 56 divisions, falling in five minutes to 42. It must be admitted that the result obtained with B was somewhat better than this; nevertheless, the effect of the sulphate in reducing the efficacy of the peroxide is sufficiently striking.

Still more so is its effect in the case of solid peroxide (lithanode), not in contact with any other simple conductor within the electrolyte. But in order to judge of the effect in this case, we must be able to analyse the lithanode chemically at the outset, and also when the E M.F. between it and spongy lead has fallen to any given extent.

A convenient and, with due care, an accurate method of determining the percentage of lead peroxide in "lithanode," or any other active material containing this oxidant, is to add cautiously the finely-powdered material to the solution of a known weight of crystallised protosulphate of iron, acidulated with somewhat more than half an equivalent of hydrochloric acid, until the solution no longer gives a blue coloration with a drop of potassic ferricyanide solution. It is advisable to triturate the powder in a mortar containing the acidulated ferrous solution at a temperature over 100° F. Of course it is generally possible, especially after a rough preliminary trial, to add at once sufficient of the powder to nearly convert the whole of the ferrous salt into ferric salt; afterwards the powder is added in minute portions until the blue coloration is no longer produced. If too much of the powder be added, free chlorine and a distinct brick-red coloration are observable. In regard to the numerical data, 7·8 grams of the ferrous salt ($Fe\,SO_4\,7\,H_2O$) are equivalent to 1 gram of chlorine or to 3·36 grams of $Pb\,O_2$.

I took a fragment of one of my old lithanode plates (marked X), of which the capacity was about 16 ampere-hours (at a potential not lower than 1·8 volt), and found by the above method that it contained 70·7 per cent. of $Pb\,O_2$. I then made use of another similar fragment of the plate as a negative element, until the difference of potentials between it and spongy lead fell to 1·8 volt. This fragment having been washed, and slowly dried at a low temperature, was reduced to powder and found to contain 55 per cent. of the $Pb\,O_2$ originally present. Only 22·2 per cent. of this quantity of peroxide had become reduced, 77·8 per cent. was apparently unaffected; and yet the reaction upon which the E.M.F. is dependent had become in some way modified, since the electrometric indication on open circuit had undergone a permanent diminution to the extent of about 10 per cent.

The weight of peroxide present in one pound avoirdupois of the original plate was $\frac{16 \times 70\cdot7}{100} = 11\cdot3$ oz. In becoming exhausted to the extent of no longer giving with spongy lead an E.M.F. above 1·8 volt, one lb. of the plate will lose 2·5 oz. of peroxide. To what number of ampere-hours does this weight of peroxide correspond?

The ampere-hour equivalent for silver, according to Lord Rayleigh's latest determination, is 62·137 grains; this equivalent for peroxide of lead would therefore be:—

$$62\cdot137 \times \frac{239\ (i.e.,\ \text{mol. wt. of}\ Pb\,O_2)}{216\ (i.e.,\ \text{twice at. wt. of Ag.})} = 68\cdot75\ \text{grains.}$$

Now the number of grains in 2·5 oz. avoirdupois being $2\cdot5 \times 437\cdot5 = 1094$, the number of ampere-hours corresponding to 2·5 oz. of $Pb\,O_2$, or to 1lb. of the "X" lithanode will be—

$$\frac{1094}{68\cdot75} = 15\cdot9.$$

It may be admitted, therefore, that when, as in the case of lithanode, local action in the negative element is entirely eliminated, the yield of the battery in ampere-hours is strictly proportionate—as might have been anticipated by theory—to the quantity of peroxide reduced in each cell.

This experimental result is interesting from other points of view than that of the electro-chemical equation of the lead storage battery. From the present standpoint of practice, 16 ampere-hours of useful capacity per pound of negative element is a splendid result. With lithanode of more recent manufacture it has been surpassed; but it has never, I think, been approached with any other form of negative element. And yet, from the theoretical standpoint, what a poor result—two and a-half ounces of peroxide utilised in one pound of negative plate containing eleven and a-third ounces of the peroxide! It is not likely that we shall stop here; there is ample room for further improvement.

It might perhaps be expected that I should suggest a battery formula in substitution for that to which I have objected. I am sorry that I am unable to do so, nor even with any degree of confidence to attempt an explanation of the fact that so large a percentage of the peroxide present in a negative element should remain useless and inert for all practical purposes. I have thought it possible that the residual peroxide of lead might be in a state of combination, that a comparatively inert sesquioxide of lead might be formed according to the equation

$$2\,Pb\,O_2 + 2H_2\,SO_4 + Pb = Pb_2\,O_3 + Pb\,SO_4 + H_2\,SO_4 + H_2\,O.$$

But although this view, on the assumption that the sesquioxide formed may resist or be protected from the action of the sulphuric acid present in the electrolyte, may explain the recovery of apparently exhausted plates when they are left in contact with the acid, I have not been able to bring it into general accordance with the results of experiment and with those obtained by chemical analysis. It should be mentioned, however, that, although it is in opposition to the experimental results obtained by Gladstone and Tribe, this view is in some measure at least confirmed by those obtained by Shenck and Farbaky. These investigators found that, in charging a lead secondary cell, 2·23 grams (34·426 grains) of $H_2\,SO_4$ become liberated per ampere-hour current; and that, in the discharge of the cell, 2·25 grams (34·736 grains) of the acid enter into combination. Now the ampere-hour equivalent of sulphuric acid is 1·826 grams (28·192 grains); and we may assume that at least this quantity enters into combination with the spongy lead positive in the production of the ampere-hour current. There would remain, therefore, only $34\cdot736 - 28\cdot192 = 6\cdot544$ grains of $H_2\,SO_4$, or ·23 of the equivalent, to combine with monoxide of lead reduced from the peroxide in the negative element. The ampere-hour equivalent weight of oxygen would be derived from this element, an ampere-hour equivalent of lead monoxide would be produced; but only ·23 of the latter equivalent would become converted into sulphate, leaving ·77 of the equivalent in admixture or in combination with residual peroxide of lead.

Having had some experience of the behaviour of sulphate of lead when used as a depolariser, I have thought it possible also that this salt might undergo an initial effect of reduction; but this view again has not been confirmed by any experiments I have been able to make. What is required is discussion on these matters. This will probably provoke other suggestions which may lead to the extension of our knowledge.

I fear I have already trespassed too far upon your attention; but I have yet to submit to your consideration, as briefly as may be, a scheme for the supply to private householders, who may be desirous of adopting the electric light on a small scale, of the electrical energy necessary to realise their wish. This would be supplied from central stations, but without

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any outlay for insulated conductors beyond the "wiring" of the actual domiciles to the extent rendered necessary by the number and position of the lamps required, in the form of charged plates—the positives being conveyed in a closed receptacle and in a damp condition, and the negatives in a dry state. Sulphuric acid also would be required; the quantity per horse-power electrical being, according to the accepted theory, 3·12lb. of H_2SO_4. I think, however, that it will be found that considerably less than this quantity—say 2lb. of the strongest commercial acid—will suffice. This acid would be supplied by the carboy; and a measured quantity would be added to each cell when the exhausted elements are replaced by fresh ones.

For each horse-power-hour electrical supplied—corresponding, we will say, to three 20-candle lamps maintained incandescent for five hours—we should have, in the stage which the practical solution of the problem has at present reached, to transport about 40lb. of battery plates. It may be safely said that the total weight to be transported would be under 45lb. The maximum distance to which this weight would require carriage would probably be under half a mile—for it would be more economical to multiply stations than to augment this distance. On the return journey, the exhausted plates and their receptacles, practically the same in weight, would have to be conveyed.

One ton weight of plates distributed would correspond to at least 56 horse-power-hours electrical. The question is, what would be the cost, under conditions of practice which admit of considerable latitude, of distributing this weight of material? Upon the answer to this question depends the extent to which this system of distributing electrical energy could be commercially developed. A small percentage of the general public, if safeguarded from all trouble, would be willing to pay even as as mush as 1s. per horse-power hour electrical. A very large percentage indeed, I am convinced, would pay 4d. for the same quantity of available electrical energy. Anywhere between these two limits a considerable amount of business might probably be done. Nothing but an actual trial of the system, on a small scale perhaps, but extending over a considerable period of time—so as to give some scope to the capacity for organisation, which has accomplished such marvels in our postal department—will give a conclusive answer to the above question. It is easy to suggest figures which would show the system to be absurdly impracticable; but, as I have elsewhere observed, it would be easy also on the same lines to show that the milkman, who, anywhere in his district, will send horse and cart, man and can, to deposit even a ha'p'orth of milk at the area door, must be financially in desperate case. But there may be some, here or elsewhere, who have had experience of work analogous to that which I have in contemplation; and their opinion, as well as the suggestions they might possibly offer, would be entitled to respect, and might be of considerable value.

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the late meeting of the British Association on various subjects connected with Electrolysis:—

ON THE APPLICATION OF ALTERNATING CURRENTS TO THE DETERMINATION OF THE CONDUCTIVITY OF ELECTROLYTES.

By T. C. Fitzpatrick, Scholar of Christ's College, Cambridge.

(*Communicated by* W. N. Shaw.)

The work described in this paper was undertaken with the view of testing the method of the alternate current as applied to the measurement of the resistance and conductivity of electrolytes.

This method was first employed by Kohlrausch and Nippoldt in 1869, and an account of their work and their justification of the method is found in Poggendorff's *Annalen*, CXXXVI. They found that above a certain rate of alternation of the current the electrolytic cell could be replaced by a metallic resistance, and that the value of this replaced resistance did not alter on increasing the rate of alternation.

Two things they considered were necessary for the complete removal of the polarisation effects:—

(*a*) A sufficient rate of alternation.

(*b*) Electrodes of considerable area; small platinised platinum electrodes were afterwards found to answer perfectly well.

The alternate current was produced by a sine inductor, and as indicator they employed a dynamometer.

In the October number of the *Annalen* for last year there is a long paper on Kohlrausch's most recent work; the method is the same as that employed in the earlier work, only the dynamometer is replaced by a telephone as indicator.

A modification of this method was used by Ewing and Macgregor. They employed the Wheatstone bridge arrangement, the current being alternated by a rocker.* They do not, however, appear to have obtained any satisfactory results.

More recently Macgregor has replaced the rocker by a double commutator. By one-half of the commutator the alternate current has been produced, and by the other the current of the galvanometer circuit has been redirected, so that through the galvanometer there is a direct but intermittent current. It is a method similar to this latter that I have employed.

My commutator, which was very carefully made by the Cambridge Scientific Instrument Company, consists of a drum, on the two faces of which are eight sectors of brass separated by strips of ebonite; the alternate sectors are connected with two brass rings on the spindle of the commutator. The only difference between the two faces of the drum is that on the one side the sectors are smaller and the ebonite pieces bigger. This is to permit of the galvanometer circuit being broken before the battery circuit, and made after it.

* Prof. Ewing traverses these statements. *See* B.A. Report for 1886.

The two rings on the one side of the commutator are connected by brushes with the poles of the battery, and two brushes carry off alternate currents from the face of the drum to the two points on the Wheatstone bridge. The brushes are kept firmly pressed in contact by springs.

The two points in the bridge for the galvanometer are connected with two brushes in contact with the other face of the commutator; and, lastly, two brushes in contact with the other two brass rings carry off the direct current to the galvanometer.

The resistance-box employed is one of Elliott's, being a legal ohm box; the galvanometer is a Thomson reflecting galvanometer, only the light mirror has been replaced by a piece of mirror-glass, which is loaded with several lead discs, and to the back is fixed a small magnet. The magnet has thus a considerable time of swing, and was found to answer much better than the usual light needle. The resistance of the galvanometer was about 268·8 ohms.

Two different cells were employed to hold the electrolyte. The first was similar to that of Kohlrausch—a strong glass beaker, in which the electrodes were kept in fixed relative positions by two small glass plates. A thermometer was inserted between the two plates to register the temperature.

Kohlrausch, to determine the resistance capacity of his cell, measured its resistance when filled with pure mercury;* but he does not mention his having taken any precautions as to the difficulty of getting a good contact between his platinum plates and the mercury. Recent observers have stated that there remains a film of air between the platinum and the mercury, and that to get good contact the cell should be filled under greatly reduced pressure; and even then I have found that the resistance may vary. I have therefore not employed mercury to determine the resistance capacity of my cell, but a standard solution of copper sulphate, the absolute values of which I determined by means of my other cell.

This consists of a glass tube of considerable cross-section which fits into two glass end-pieces; the tube has been ground so as to protrude about an inch into the end-piece. The apparatus was made for me by Messrs. Powell, of Whitefriars Glass Works, and possesses the advantage of being entirely of glass, without any corks, &c. And the electrodes were firmly pressed against the ends of the tube, and so the resistance of a given column of the solution determined.

For electrodes, in the first instance, copper plates were platinised. For a long time no satisfactory method of platinising could be found; that which gave the best results was the electrolysis of a solution of platinum chloride and nitric acid; the deposit thus obtained was fairly adhesive.

It was finally found best to obtain some platinum electrodes, and for this purpose two platinum shoes were made by Messrs. Johnson and Matthey, into which fitted thick copper plates; thus a strong electrode of small resistance was obtained without the expense of thick platinum plates; these plates were slightly platinised as above described.

In the early experiments with this method no satisfactory results could be obtained. When the electrolytic cell was introduced into the fourth arm of the Wheatstone bridge sometimes the galvanometer would not give any steady deflection, and it was impossible to get a balance. This was similar to Macgregor's experience; he states that by introducing another cell into one of the other arms of the bridge he readily obtained a steady deflection. In my own case this did not in the slightest diminish the effect; even with a metallic resistance in the fourth arm of the bridge the same value could not be obtained as when the commutator was not working.

Under these circumstances it became necessary to thoroughly investigate the action of the commutator. At first the commutator had been lubricated with a small quantity of oil; this was found to be partly the cause of the effects observed, and it was consequently thoroughly cleansed from all oil.

It was also found that the commutator did not run perfectly steadily; the commutator and its stand were therefore firmly fixed in position with wooden props, and driven by a water-engine, which was supplied with water from a tank at the top of the building, and thus a constant and steady speed was obtained.

Finally, as above described, the light needle of the galvanometer was replaced by one with a longer time of swing.

With these alterations it was found that the galvanometer gave a steady deflection, and the method appeared to be satisfactory.

This result having been obtained, the apparatus was tested for induction effects. For this purpose a metallic resistance was introduced into the fourth arm of the bridge, and its value determined when the commutator was not working; the value obtained was—

$$R = 19{\cdot}91 \text{ legal ohms.}$$

With the commutator working at varying rates of speed, the value remained the same, and was not altered by changing the battery power from that of 2 Leclanché cells to a tray of 10 Daniells. This seemed satisfactorily to show that there was no induction effect, though the sensitiveness of the galvanometer was diminished.

The diminution in the sensitiveness of the galvanometer when the commutator was working may be seen from the following series of observations.

The above metallic resistance being in the fourth arm of the bridge, a balance was obtained when the value of the resistance of the third arm was 1991, the value of the other two arms being 1000 and 10 respectively.

* Prof. Kohlrausch corrects this statement. *See* B.A. Report.

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(1) Commutator at rest—

Galvanometer zero 28·3 cm. } deflection of 16 mm.
50 ohms in 3rd arm 26·7 }

Zero . . 28·3 } deflection of 32 mm.
– 100 ohms . 25·1 }

(2) Commutator working—

Zero . . 28·5 } 5 mm. Zero . . 28·5 } 9 mm.
– 50 ohms . 29 } – 100 . . 29·4 }

Hence the sensitiveness of the galvanometer is decreased by about $\frac{2}{3}$ when the commutator is working, though the rate of driving did not appear to affect the sensitiveness. The apparatus was then tested for polarisation effects. For this purpose the two wires leading from the commutator to the battery circuit were connected with the galvanometer and an electrolytic cell with platinum plates containing copper sulphate; the commutator was started and the circuit completed, the battery consisting of 2 Leclanché cells; the commutator was allowed to run for two hours and a half, the rate of alternation being about 120 per second; at the end of this time the circuit was broken, and the platinum plates washed, treated with hot nitric acid, and ammonia added after neutralisation with ammonia carbonate. There was not, however, a trace of blue coloration; it was therefore clear that no copper had been deposited on either plate, and that there was no cumulative polarisation effect.

This test was again repeated, the platinum plates being replaced by platinum wires, and the Leclanché cells by a tray of 10 Daniells; the commutator was allowed to work for over three hours at the same rate of 120 alternations per second. At the end of this time the wires were treated similarly to the plates, but with the same result. This latter was a more severe test, and would tend to show that the method may be expected to be free from all polarisation effects, and to give satisfactory results.

So far, therefore, this method seems perfectly satisfactory, and with the arrangements as above described, I have not found it in the least necessary to have a second cell in the bridge, as did Macgregor.

I find that the steadiness of the galvanometer depends—

(1) On the commutator being perfectly clean.

(2) On the commutator being driven at a steady speed, though permanent alteration in the rate of speed does not affect it.

Having thoroughly tested the method for polarisation and induction, I proceeded to examine into the question of contact resistance, a subject which has been raised lately by Dr. Gore, several papers on the subject being published in the *Philosophical Magazine* for this year.

It seemed that if there was such an effect as contact resistance it was impossible to obtain the absolute values for the conductiveness and resistances of different solutions, and that before proceeding to the measurement of these quantities it was necessary to test for contact resistance.

For this purpose I filled one of my cells with copper sulphate solution, and determined its resistance value with different pairs of electrodes.

These were—

(*a*) Platinum plates (slightly platinised).
(*b*) Platinised copper electrodes.
(*c*) Amalgamated copper electrodes, or copper electrodes with freshly deposited copper surface.

I found that the amalgamated copper electrodes left in a solution of copper sulphate became coated with a film of copper, mercury apparently going into solution; this of course was only to be expected from the chemical ideas of mass action.

The values obtained were—

(*a*) Patinum electrodes, 469·2 at 16·9°.
(*b*) Platinised copper, 469 at 17°.
(*c*) Copper electrodes, 471·95 at 16·7°.

These same copper electrodes gave after standing in air or copper sulphate solution a value much bigger than that of the platinum plates.

Another pair of copper plates, which had been prepared some days, gave the values with a different copper sulphate solution of—

(1) Copper plates, R = 477 at 17·6°.
(2) Platinum plates, R = 465 at 17·4°.
(3) Platinised copper 465 at 17·4°.

It appears, therefore, that the platinum and platinised copper plates give identical values, and it would appear that the value given by copper electrodes with a fresh metallic surface is almost the same; but that due to oxidation in air or in the solution the surface is changed, and as a consequence the resistance value much increased.

This would tend to show that with clean metallic surfaces, and the same solution, the resistance value is the same, and that there is no contact resistance, or at least that it is the same in all three cases. To further examine this question I determined to experiment with a solution of zinc sulphate with

(1) Platinum plates.
(2) Amalgamated zinc electrodes.

Two zinc plates were freshly amalgamated, and left over night standing in a solution of zinc sulphate, and when introduced into the cell they gave a value

R = 312 at 16·4°.

The platinum electrodes gave the value

R = 280 at 16·5°.

After again standing in the zinc sulphate solution the value for zinc plates was

R = 318 at 16·5°.

These same electrodes were then washed with dilute sulphuric acid, to dissolve off the film of zinc or oxide, and after careful washing were introduced into the cell; the value now came down to

R = 286 at 16·5°.

In this case too it would appear that with a pure metallic surface the resistance value would be the same, whatever the electrodes used.

Such being the case, it becomes very necessary, in the determination of the conductivity of electrolytes, to take account of the character of the electrodes, and at the same time the above observation would point to the fact that with pure metallic surfaces the effect of contact resistance is constant, if it occurs at all.

Again to further test this point, the absolute value of a certain copper sulphate solution was determined by employing two distinct cells.

(1) Cell A: the tube of this cell had a length of 31·4 cm., its mean section being 10·66 square cm.

The copper sulphate solution placed in this cell gave a resistance value or 504·5 legal ohms at 18·1°.

(2) Cell B: the tube of this cell had a length of 24·16 cm. and a mean section of 13·21 square centimetres.

The copper sulphate solution placed in this cell gave the value 306 9 legal ohms at 18°.

The same platinum electrodes were used in both cases.

The values obtained for the resistance of a cubic centimetre of the copper sulphate solution differed by about 2 per cent.

The values being, with cell A

R = 171·2 legal ohms.

With cell B

R = 167 8 legal ohms.

These results would again tend to show that there is no effect due to contact resistance.

Another point, which seemed of importance, was the action of the solvent in the conductivity of electrolytes, and with the view of experimenting on this subject, solutions were prepared containing the same salt, whilst the solvents were different.

In the first place equal quantities of copper sulphate were dissolved in distilled water and in glycerine, the resistance of the two solvents having been previously determined.

(1) The resistance of 500 cm. of water introduced into the cell gave a resistance of R = 12,780 legal ohms; in this water was dissolved 6·625 gms. of hydrated copper sulphate; the resistance value was now R = 8·87 legal ohms at 17·2°.

(2) The glycerine, which was not pure, gave the value

R = 181,000 legal ohms.

In this was dissolved 6·625 gms. of hydrated copper sulphate, and the resulting value was

R = 27,850 at 16·8°.

From these results the conductivity of a solution would appear to a large extent, and in fact mainly, to depend on the solvent employed. The comparison of solutions of copper sulphate in water and glycerine was not, however, continued, as there appears to be some slight chemical action whereby a very small quantity of copper oxide is precipitated; and, hence, it was thought that this would not be allowed perhaps to be a case of solution similar to that of the copper sulphate in water.

The case, however, of solutions of calcium chloride in water and absolute alcohol appeared to be in every way comparable, as a definite crystalline compound of calcium chloride and alcohol exists similar to the hydrated crystalline chloride. For this purpose equal quantities ($\frac{1}{10}$th of an equivalent) of pure anhydrous calcium chloride was dissolved in 500 ccm. of water, and also absolute alcohol (sp. gr. ·795), the resistance of the alcohol and also of the water having been previously determined. Then by dilution solutions were prepared of 250 cc., containing $\frac{1}{10}$, $\frac{1}{20}$, $\frac{1}{40}$, &c., of an equivalent of the salt in 500 cc. of the solvent.

Two series of values were thus obtained for solutions of different dilutions in both alcohol and water, wherein we can compare the action of the two solvents.

Solvent alcohol:—

Conductivity of alcohol at 17·8° = ·00000268.

In each case 250 ccm. of solution was introduced into the cell.

Amount of salt contained in 250 ccm.	Conductivity.	Temperature.
$\frac{1}{20}$ E.	·0007273	18·7°
$\frac{1}{40}$ E.	·0004820	18·7°
$\frac{1}{80}$ E.	·0003055	18·8°
$\frac{1}{160}$ E.	·0001939	18·6°
$\frac{1}{320}$ E.	·0001178	18·6°
$\frac{1}{640}$ E.	·0000729	18·6°
$\frac{1}{1280}$ E.	·0000430	18·6°
$\frac{1}{2560}$ E.	·0000259	18·5°

Solvent water:—

Conductivity of water at 19·8° = ·00000848.

Amount of salt contained in 250 cc.	Conductivity.	Temperature.
$\frac{1}{20}$ E.	·015574	18·8°
$\frac{1}{40}$ E.	·008736	18·8°
$\frac{1}{80}$ E.	·004634	18·6°
$\frac{1}{160}$ E.	·002445	18·4°
$\frac{1}{320}$ E.	·001307	18·9°
$\frac{1}{640}$ E.	·000689	18·9°
$\frac{1}{1280}$ E.	·000364	19·3°

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To determine the temperature coefficient of two comparable solutions $\frac{1}{10}$ of an equivalent of dry calcium chloride was dissolved in 250 ccm. of alcohol and water respectively, and the values of the two were determined at two different temperatures.

(1) Alcohol solution :—

$\frac{1}{10}$ E. in 250 ccm. solution in cell gave a resistance value of

236 legal ohms, at 19·4°

250 ,, ,, 13·6°

Increase of resistance of 14 for 5·8° C.

This gives a temperature coefficient of ·00102.

(2 Water solution :—

250 cc. in cell gave value

R = 14 0 at 18·3°.

= 15·4 at 14°

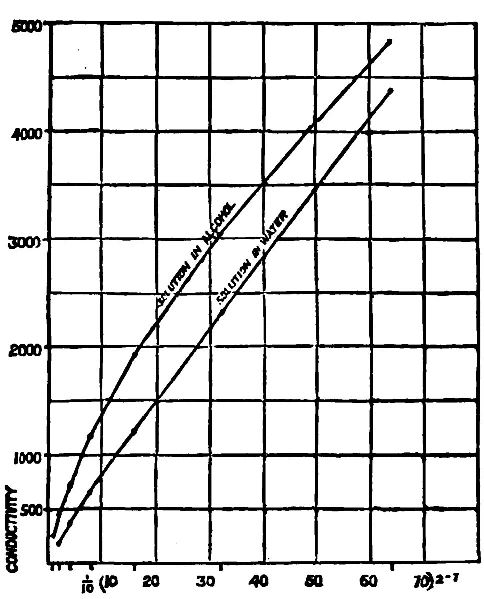
Increase in resistance 1·4 for 4·3°.

This gives a temperature coefficient of ·0023.

The results obtained with the two series of solutions have been plotted on curves ; that for the water solution is apparently a straight line, and would tend to show that for solutions of such dilution the conductivity is proportional to the amount of salt in solution ; the same does not, however, appear to be true in the case of the alcohol solutions.

This is a point which of course needs further investigation, and I intend to experiment further on this subject with different solvents and the same salt.

In conclusion, I have to thank Mr. W. N. Shaw for the kind help and advice he has given me in all this work.



Quantity of salt in equivalents per litre.

In curve for water and $CaCl_2$ each division measured vertically represents ·0001 increase in conductivity.

In curve for alcohol and $CaCl_2$ each division corresponds to ·000005.

THE ELECTRIC LIGHTING BILL AND THE CORPORATIONS.

Yesterday, at the meeting of the Association of Municipal Corporations, held at the Surveyors' Institution, the question of the Electric Lighting Bill came up for consideration. Mr. Woodall, M.P., presided.

An animated discussion took place on the motion that the Bill be referred to the council.

Sir George Morrison (Town Clerk of Leeds) said it would be within the cognisance of most of them that the Town Clerks of Nottingham, Birmingham, Newcastle, Leeds, and other towns gave evidence before the House of Lords Committee on the Electric Lighting Bill which was presided over by Lord Houghton. Although there was a strong feeling against them upon the committee itself, they succeeded in making what they thought were fair and reasonable terms between the Government on the one side and the Corporations on the other. They agreed upon an extension of twenty-one years to forty-two years, but it was distinctly understood that nothing should be allowed for goodwill. Moreover, it was practically agreed between the Board of Trade and the Corporations that the consent of a Municipal Corporation should be a condition precedent to the granting of a provisional order, unless, indeed, that consent should be unreasonably withheld, and that the Board of Trade thought it was an improper withholding. It seemed to him that these were fair terms; but in Lord Thurlow's Bill, now before the House of Lords, there was no clause making the Corporations' consent a condition precedent, and the term was extended from twenty-one to forty-two years. Then there was an express clause that Corporations after forty-two years should pay for the goodwill. That provision ought to be strongly opposed by the Corporations. Lord Houghton, who represented the late Government, agreed to what the Corporations thought fair, and he urged the Corporations to insist upon a clause to this effect: "Notwithstanding anything in the Electric Lighting Act, 1882, no provisional order authorising the supply of electricity by any undertakers within the district of any local authority shall be granted by the Board of Trade except with the consent of such local authority, unless the Board of Trade in any case in which the consent of such local authority is refused are of opinion that, having regard to all the circumstances of the case, such consent ought to be dispensed with, and in such case they shall make a special report stating the grounds upon which they have dispensed with such consent." They were entitled to have that clause in accordance with their agreement of last year. With regard to goodwill, nothing ought to be paid by the Corporations.

The Town Clerk of Birmingham wished to accentuate the views of Sir George Morrison, whom they had to thank for the ability with which he laid their case before the committee.

The Town Clerk of Newcastle (Mr. Hill Motum), as one who had given evidence before the Lords Committee against the interests of electric lighting, cordially supported the remarks of the Town Clerks of Leeds and Birmingham, and he hoped that all Corporations would petition against the Bill. His own Corporation had taken action against it. Lord Thurlow had said that it was on the lines of last year's Bill; but it carefully inserted all the clauses in favour of electric lighting companies, and eliminated those in favour of Corporations.

The Town Clerk of Blackburn also supported opposition to the Bill.

Sir James Picton (Liverpool) was afraid that their action would have the effect of stopping all progress in electric lighting.

Sir George Morrison said that Sir James Picton's remarks sounded strange after the evidence of the engineer of the Corporation of Liverpool against the view now taken by Sir James Picton.

The Bill was then referred to the council.

COMPANIES' MEETINGS.

Western and Brazilian Telegraph Company (Limited.)

The fourteenth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on the 8th inst., Mr. C. W. Earle in the chair.

The Secretary (Mr. R. M. Cunningham) read the notice calling the meeting, and the minutes of the last meeting, which were approved by the present meeting, and signed as correct by the Chairman.

The Chairman : Gentlemen, you were informed at the last general meeting that in the absence of Sir Henry Drummond Wolff on a very important mission the remaining Directors had undertaken to do his duty, and to rotate the chair. We expected—in fact we have for some time expected—that the right hon. gentleman's mission would terminate. He was at home here during the autumn for some months, and seeing the probable speedy termination of his occupation—which I believe he is carrying on with the entire satisfaction of his own Government—we have not thought it advisable to make any change in the chairmanship of the Company. It is owing to this arrangement and these circumstances that I have the honour of addressing you. I presume that you will, as usual, take the report and accounts as read. The accounts, as you were informed by circular, for the purpose of bringing ourselves into accord with the other telegraph companies with whom we exchange accounts, have been extended to include a period of 15 months, instead of the usual 12 months. For the purpose of facilitating comparison, the account has been divided so as to show clearly what the 12 months' expenditure and receipts have been ; and also the result of the three months' working, which have been included in the operations which we report to-day. As to both the receipts and expenditure of the final quarter, it will not be wise to multiply by four so as to get at the average of what the result would be for the year. There seems, as to receipts, to be some abnormal increase in the amounts brought in for the three months. Whether it is the immunity from interruptions which the Company has enjoyed through the improvement which has been made in its cables, or whether there was some particular increase in the commercial business of the Brazils, is not very clear to us here ; but at any rate the increase is very large, but I should warn you against multiplying the result shown by four to get at what the year's revenue would be. On the other hand, the same remark would apply to the three months' expenditure, because in the expenditure for that period there are a number of charges which would extend over six months or a year, as the case might be. For instance, considerable supplies of stationery were sent out. Owing to the great increase of traffic our stock out there ran low. That is a charge that might probably cover a year or two. Certain rents also fell due, and had to be paid in that time, which swelled the expenditure disproportionately to what it will be for the year. The whole result of the fifteen months' working, I think you will admit, is very satisfactory in comparison with anything we have been able to show you before in this Company. Although there is a diminution in the twelve months' receipts when compared with those of the preceding year, it must be remembered that in that year a very large increase was reported. As much as £21,000 more was earned in 1885 than in 1884, and, therefore, we are comparing in respect of the twelve months with a time of very large increase. There is also another fact to be considered, namely, that in the month of May a further reduction in rates was made. We are in competition with the land lines of the Brazilian Government, and we had to follow every lead

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in the matter of reductions, or we should lose traffic. As it is, it is very satisfactory to find that we are taking 90 per cent. of the traffic in that country—a fact which speaks volumes for the reliance which the Brazilians place on our lines as compared with their own, and the rapidity and despatch with which our business is conducted. Although there was this small decrease in the receipts of the year it was very largely recouped by the great increase in the last three months, as stated in the report. The question of the exchange enters as a factor into what we take. We are obliged to take the coin of the country at its nominal value, and of late years the exchange has been very much against us. It is now improving, and that, for what it is worth, has tended to increase the receipts for the last three months embraced in the accounts now submitted. In 1885 the loss on exchange was over £10,000; but in these 15 months we are now discussing, the loss on exchange was only about £9,000. That shows an improvement in that respect which affects the traffic returns favourably. On the expenditure side of the accounts it is very satisfactory to note a decrease of £4,612 in the 12 months in comparison with the expenditure of the preceding 12 months, which, I may remind you, showed a decrease over the then preceding year of some £1,700. As I have already said, the expenditure of the final three months in the accounts is hardly a fit subject for analysis at present, on account of exceptional payments which have fallen into that period. With reference to the details of these accounts, I propose just to give you a few figures. In abstract A there is an increase of £890. This is principally made up of an increase in the salaries and wages paid in the Brazils. The clerks' agreements contain stipulations for advances, several of which took place in that period, and there were extra allowances on account of overtime, consequent on the very large increase of business prolonging their duties into the night. At one station we were called upon by the Government to keep open all night, and we have had to pay men for sitting up all night doing the extra work. It has been our policy, in view of the competition in which we are engaged, and the necessity of keeping up an active staff, to treat the *employés* of the Company liberally. The other items in Abstract A are almost insignificant. There is, however, one for medical allowances, which shows an increase of £155. That was owing to the unhealthiness that prevailed. There is a decrease in the cost of the maintenance of land lines, owing to the shore ends having had to be dealt with in the accounts of the preceding year. Beyond that I do not know that there is anything to remark on in Abstract A. With reference to Abstract B, the expenses of the "Viking" are increased by £2,400. As she was the only ship on the station while the "Norseman" was at home, she had to burn more coal. Still, there is a decrease in this abstract of £4,152. In regard to Abstract C there is a decrease almost all along the line. Salaries and wages at home exhibit a decrease of £588, and travelling expenses were £285 less. The law charges show a decrease of £341, because we had less law. Although there is a decrease in this abstract of £1,284, I may say while on this subject of revenue and expenditure, that the increase in the volume of traffic has continued into the current year. For the last two months, January and February, compared with the same months of 1886 there has been an increase of 45½ per cent. in the traffic—in the traffic, observe—and this has given a money increase of 23 per cent. To show you the increase that has been going on, I may tell you that in 1884 we carried 100,592 messages, in 1885 the number had increased to 114 813, and last year there was a further growth to 130,773. That shows a very steady progress; and, in fact, whether we look at the improved condition of our cables, owing to the removal of the old type of cable (and there are now only about 200 miles of the old type in our system of 4,000 miles), or whether we look at the important collecting ground we occupy, or at the improvement we are showing in the traffic, I think our position is now a very strong one. And this brings me to a subject which excited some interest last year—I refer to the negotiations with the Brazilian Government. Practically, the negotiations with the Government have not proceeded; and I may say that they are in abeyance. We never were, during last year, in communication with the Government themselves. What took place was that proposals were submitted to us by other parties interested in the matter; but they have as yet come to nothing. But looking at our position—the much stronger position we are in—the improvement in our cables, and the increased revenue we are showing, I think we are in a much better position to deal with any parties who wish to acquire this property, than we were when we met you this time twelve months ago. He then concluded by proposing the adoption of the report and accounts.

Major WOOD seconded the motion.

Mr. GUESDON asked what was the position of the negotiations for making a sale of the property to the Brazilian Government. He also inquired whether any arrangement or agreement had been made by the Manging Director, Secretary, and all or any other of the officers of the Company in the event of the Brazilian Government being purchasers—he meant with reference to compensation. He further asked whether any alteration had been made in the emoluments to the Managing Director and Secretary since they took office, and what was the total increase in each case, and when made. He also asked the following question:—Did the Managing Director and Secretary receive any gratuity for bringing up the statement of misappropriations which led to the recovery of a large sum of money and shares, and if so, what was the sum which each received, and was it stated distinctly as a payment to each of those officers in the report and statement of accounts? He knew that payments were made which did not appear in the accounts, which were made up in a way susceptible of great improvement. He believed that a sum so paid was included in the last year's accounts which should have been submitted to the shareholders, who, he believed, would have passed it; but he thought that abnormal expenses had no right to be incurred by the Directors and officers of the Company without the sanction of the shareholders. The information imparted to the shareholders as to the expenses, salaries, and wages should be increased. He thought that the Manager's salary and that of the Secretary ought to be disclosed, and every other information as well that could be given to them. He also wished to know why Mr. Heugh was to be re-elected.

Major WOOD: Mr. Heugh resigned ten years ago. [Much laughter.]

Mr. GUESDON: The information as to the negotiations with the Brazilian Government had been in suspense—he did not know how long—and there were facts in connection with this matter which afforded a very strong reason why the Brazilian Government were anxious to buy the Company's property. It became especially important for that Government to give the Company a price for their property, by the acquisition of which the Brazilian Government would be able to make a profit instead of a loss on the working of their lines. It seemed to him that the time had arrived when it would be in the interest of the shareholders to see if some negotiations could not be carried out to make the Brazilian Government become the owners of their property. He did not believe that the negotiations for the sale of the undertaking would ever be carried out till they had a committee, or some independent body, to go into the question, as self-abnegation was no part of the policy of Directors. With regard to the issue of proxies, that was illegal, and it was a liberty to issue them and charge the Company with the expense.

Mr. H. WEAVER (a Director): We pay the expenses ourselves.

Mr. GUESDON: I say it is a liberty to issue them then.

The CHAIRMAN: It is a liberty we shall continue to take.

Mr. GUESDON said that that could be done, seeing the autocratic position of Directors; but a great improvement would be effected in connection with this matter if shareholders in companies would take as much interest in them as they did in politics. Having spoken in favour of half-yearly meetings he moved the following amendment:—"That in future the report and statement of accounts be made up to the 30th of June and the 31st December, and that half-yearly meetings be called to receive them as soon as practicable afterwards." He did not see why they should be kept a year—and on the present occasion it was fifteen months—before they learned anything of the position of the Company.

A SHAREHOLDER inquired when the new cable was expected to be completed, and if, when it was completed, either of the ships would be disposed of.

The CHAIRMAN replied that they were not going to touch the 200 miles of cable he had referred to. That portion was in deep water. They could not get on with one ship.

Mr. GRIFFITH said that the question of the issue of proxies was a very interesting one. He had been reading the previous day the very important judgment given on the matter by Mr. Justice Kay, who based his decision on two grounds. First of all, it was a positive misapplication of the Company's funds to issue proxies at the expense of the Company, whether in stamping them or in enclosing them in an envelope; and, secondly, because the issue of proxies was an undue exercise of power by Directors to attempt to influence the votes of shareholders. Mr. Justice Kay said that the printed form of proxy might be sent out, but that he was against sending out a proxy in which the names of the Directors were inserted. Mr. Justice Kay added that the custom of companies might be universal, yet no mercantile custom could establish what was illegal. Until the decision of Mr. Justice Kay was altered by the Court of Appeal, which he thought was not likely, it was the law. He agreed on the advisability of holding the meetings of the Company half yearly, and that they should have two dividends in the year, some companies having gone so far as to pay quarterly dividends For the rest he thought the shareholders might congratulate the Directors that they were enabled to present such a gratifying report. There was no doubt a great improvement in the Company, which it was to be hoped would be still further increased. He thought the renewal fund was rather small compared with the capital spent, while he was not in favour of overgrown exorbitant renewal funds, as in the case of the Anglo-American and other companies. On the other hand, a due insurance of their property was necessary. Perhaps the Directors were more competent to judge as to whether £135,000, increasing gradually, was sufficient. If that was their view he would take no exception.

Mr. GUESDON said he had omitted one point which he had intended to bring before the meeting. There were two clauses in the Articles of Association which he thought must have escaped the notice of the Directors in the alterations they had made, but which he thought should never have been kept. The first was Clause 7, which was as follows:—"Any Director or officer, either individually or as a member of a partnership, company, or corporation may be interested in any operation, undertaking, or business, undertaken or assisted by the Company, or in which the Company is interested, and no Director or officer shall be disqualified to act by reason of his being so interested, and as a Director he may vote on all matters relating to any such undertaking or business in which he is interested as aforesaid, notwithstanding his being so interested." That was a sort of thing which could not be done under the Government. The other clause was simply a disgrace to joint-stock enterprise. He referred to the latter part of Clause 26, which was as follows:—"Notwithstanding any rule of law or equity to the contrary, no Director shall vacate his office by reason of his being concerned in, or participating in, the profits of any contract with the Company, and no contract or arrangement entered into on behalf of the Company with any Director shall be avoided, nor shall any Director be liable to account to the Company for any profit realised by him from any contract or arrangement by reason only of his being a Director or by the fiduciary relation thereby established." He maintained that these two clauses ought not to exist in any company.

Major COTTON, replying to the last speaker, said that as to any remuneration given to the Managing Director or Secretary under the circumstances mentioned, he (the speaker) was present at the time when 700 shares were given to the Board. That was by a vote of the shareholders, and it was done by a majority of those present, and when a measure of that kind had

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been once done there should be an end to the matter. It was a mistake to raise such questions again. The present accounts were highly satisfactory, and he was very sure that the shareholders ought to feel greatly obliged to the present Board, the Managing Director, and the Secretary for having obtained such a very large return for them from the Company as it was originally formed. No one could wish that the Articles which had been read should be kept, and he was sure that if it was the general wish of the shareholders the Directors would be willing to abrogate the Articles in question [hear, hear, from Major Wood]. The attention of the shareholders ought to be called to the fact that the Articles read were dated 1873, and the present Directors had had nothing to do with them [hear, hear]. As to the negotiations with the Brazilian Government, the Chairman had already stated that they were in abeyance, and if any other negotiations were carried out, they were generally of a very delicate nature, and the less said about them publicly the better [applause]. He felt sure that Sir Henry Drummond Wolff would before long be returning, and he was convinced that such negotiations could not be in better hands than those of the right hon. gentleman and the Board.

Mr. SUTTON said he agreed that bygones should be bygones, but he was very disappointed at hearing, as he had that day for the first time, that there had been no negotiations with the Brazilian Government.

The CHAIRMAN: I mean direct negotiations with the Brazilian Government.

Mr. SUTTON said he understood a negotiation to be a negotiation whether direct or indirect, and he remembered that Sir Drummond Wolff at one of their meetings about three years ago stated that negotiations were going on, and that he had spoken to Lord Granville, or that Lord Granville had spoken to someone in authority in connection with the negotiations that were then going on with the Government. Either that was the fact, or what the Chairman stated now was not the fact.

The CHAIRMAN said there was nothing inconsistent in the two statements.

Mr. SUTTON contended that the information ought to be given to them, and that they had all waited very patiently for it.

The CHAIRMAN, referring to Mr. Guesdon's remarks, said he did not think that that gentleman could have heard what he (the Chairman) had said about the negotiations. What he had said was that they were in abeyance. He did not think that anyone would recommend them to go to the Brazilian Government and implore them to buy the Company's property. The Directors had stated their terms. They could not, however, pursue a buyer. Perhaps the parties had other views. As to the remark of Sir H. Drummond Wolff, that was made some time ago. As soon as they had the means of telling the shareholders, they stated the position of the matter—that the negotiations were, at any rate, in abeyance. It was a very good thing that that was so, for the Company were now in a much better position to come to terms with any Government or anyone who wished to buy [applause]. There had been no arrangement with the Managing Director or other officers for compensating them; and with regard to the officers' salaries, they had been the same for years.

Major WOOD, replying to other questions put by Mr. Guesdon, said that at a general meeting £1,500 was voted to him (the speaker), and £750 to Mr. Cunningham. That was a unanimous vote, given by the Board, and ratified by the shareholders, Mr. Guesdon being present [laughter].

The SECRETARY said it was announced in January, 1883.

Major WOOD said that at the following meeting Mr. Guesdon was present when the minutes were read and confirmed.

The CHAIRMAN said that they had been approached through certain parties in London to know what they would take, and after considerable negotiations the Directors said they were prepared to recommend a sum to the shareholders for acceptance. That was a long time ago, about 15 months; but since then they had heard nothing.

Mr. GUESDON observed that from what the Chairman stated no one could form an opinion what the sum was.

The CHAIRMAN said that with regard to the question of fees that was a matter that was always brought up by Mr. Guesdon. The present Board had joined the Company when it was in the direst distress, and he thought the only point for regret was that they had said they would take £1,500 for their services. They were not purchasing any new cable, and they had replaced all the cable they intended to replace. The only portion of the old stranded cable lay at a very great depth of water. It tested well, and so long as that was so they would keep it.

Major WOOD said that the portion referred to was in full working order. When it broke they would renew it, but they hoped it would not break for a considerable time.

The CHAIRMAN, continuing, remarked that with respect to half-yearly meetings the Articles of Association specified that there was to be one general meeting in the course of the year. If the shareholders wished it, they could take the ordinary steps to amend the Articles in that respect, but for his part he did not think that any great advantage was to be gained.

Major COTTON said that if the Directors saw their way to paying an interim dividend that would probably be regarded as sufficient [applause].

The CHAIRMAN observed that they had done that once, and they had power in the Articles of Association to pay quarterly dividends. With reference to the renewal fund, the auditor (Mr. Weise) stated that he thought the renewal fund was ample. It was a matter of calculation, and depended very much upon the newness of the cable, and, therefore, there was not the necessity, which there otherwise would be, for a large renewal fund. They had practically renewed the whole system since they had been on the Board [hear, hear].

Mr. SUTTON stated that his remarks as to the half-yearly meetings were made by way of suggestion, and he was sorry to find that they had been received in rather a hostile spirit by the Directors. He thought it was the duty of the Directors to consent to the unanimous wish of the shareholders.

The CHAIRMAN said that they would take the matter into consideration. There was no desire on the part of the Directors to oppose the wishes of the shareholders [hear, hear]. The meetings caused some expense. As soon as they had a revenue which would enable them to divide it into two parts they would do so. He then put the motion, which was carried. Continuing, he moved the declaration of the dividend recommended of 13s. a share, or at the rate of £3. 9s. 4d. per cent. per annum for the fifteen months, giving to the preferred ordinary shares 5 per cent. for the fifteen months, or 9s. 4½d. per share, and 3s. 7½d. per share on account of arrears for the year ended September 30th, 1884.

The SOLICITOR (Mr. Bompas) stated that Mr. Griffith (who had left the meeting) had said that he had on the previous day carefully read Mr. Justice Kay's decision on the question of the issuing of proxies by Directors. Mr. Griffith, however, must have read the decision very carelessly, because the facts to which he had referred did not exist [much laughter].

Major WOOD proposed the re-election of Sir H. Drummond Wolff. Major Cotton had made some remarks anticipating what he himself had been going to say on that matter. Sir Henry had more than once tendered his resignation; but he (the speaker) was glad to say that the right hon. gentleman had allowed him to propose his re-election that day, and he was only too glad to accept the responsibility of so doing. Sir Henry was in London not long ago, and was of the greatest use to him and the shareholders. Respecting the negotiations alluded to, Mr. Sutton had said the shareholders had been most patient, and he would ask them to be patient a little longer. He looked to Sir Drummond Wolff's influence in this matter as of paramount importance to them. There was no sentiment in the matter but simple business.

Mr. WEAVER seconded the motion.

The CHAIRMAN put it, and declared it carried with two dissentients.

Major WOOD then took the chair, and proposed the re-election of Mr. Earle, whose services he warmly recognised.

The motion was seconded, and supported by Messrs. Guesdon and Sutton, and carried unanimously.

The Auditors having been re-appointed,

Mr. SUTTON proposed a vote of thanks to the Chairman.

Major COTTON, in seconding the motion, desired, in very complimentary language, to include the other Directors, the Managing Director, the Secretary, and the other officers of the staff, and the motion having been agreed to,

The CHAIRMAN briefly acknowledged the compliment, and the proceedings terminated.

Maxim-Weston Electric Company (Limited).

Mr. Hugh Watt, M.P., presided over the ninth annual general meeting of the shareholders of this Company, which was held at the Cannon-street Hotel on the 4th inst.

The SECRETARY (Mr. John Wright) read the notice convening the meeting, and the report and statement of accounts were taken as read. It stated, *inter alia*, as follows:—"The Directors have much pleasure in stating that their operations during the past year have resulted in a profit of £3,366. 12s. 2d., after deducting all expenses. The total balance available at the credit of profit and loss account, including the amount brought forward from last year, is £3,964. 1s. 10½d. The Directors recommend the payment of a dividend of 5 per cent., which will leave the sum of £164. 1s. 10½d. to be carried forward to next year."

The CHAIRMAN said that they were very busy at the present time with the number of estimates and letters which had to be gone through, and that fact rendered it more convenient to him that they should meet at 12 instead of 2 o'clock, as was their custom. He hoped that the earlier hour of meeting had not inconvenienced the shareholders. He thought that he might venture to congratulate them on the position of affairs, and on the fact that for the third time the Directors had seen their way to recommend a dividend. It was almost unnecessary for him to state that they occupied a position unique, and he might almost say anomalous, not only in England but also in Europe, in being able to recommend to the shareholders a dividend, which he thought he might regard as substantial, out of the profits earned. He did not wish to repeat the old hackneyed phrases with regard to the existing depression of trade, as all traders were conversant with that fact, but that a new industry like electric lighting should be affected by the depression followed as a natural sequence. There was another element which had operated very adversely to the progress of electric lighting in this country, and that was the unfortunate legislation which had taken place in 1882, and as the chairman of another company referred the other day very fully to the steps which were now being taken to bring about a better state of things he did not think it necessary to say more than that they had very good reason to hope that during the present session of Parliament the existing restrictions to the progress of the enterprise would be removed. The noble chairman of the Anglo-American Brush Corporation had introduced a Bill into the House of Lords which had passed the second reading, and he himself before that gave notice in the House of Commons of a Bill which he might state was by no means antagonistic to the measure introduced by Lord Thurlow; in fact, he had been in communication with his lordship. He considered Lord Thurlow's Bill inadequate to meet what was required to remove the existing restrictions; but if the Bill were not mutilated in committee his own (the speaker's) Bill would be withdrawn. He had been trying, as far as possible, by communications and personal interviews with corporations, local bodies, and so forth, to represent the advantages of those local bodies taking up electric lighting themselves, of course under the Act, and of course recommending the Maxim Weston system as the best and most suitable, not only for public but also for domestic lighting There was one very unfortu-

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nate condition of things which the shareholders must be conversant with, namely, the disastrous litigation which had been going on during the past year. He was very pleased to say that the Maxim Company had had no active part in that litigation, either as plaintiffs or defendants. They had not been attacked, nor were they in the habit of attacking others; but he thought they would be able to maintain their rights if they were attacked. They had, on their part, never attempted to infringe any other patents. Their patents had been recognised *in toto* in the United States, and what they maintained were their patents were theirs exclusively. At the same time he might say that, for his own part, as he had stated at the last or one of the recent meetings of the shareholders, he was distinctly favourable so far to the contention of the Edison Company. That company, like the Maxim Company, had expended very large sums on patents, and he failed entirely to see why those patents should not be maintained—he did not say to the extent of their claims, but he held that their distinct patents should be maintained, and he thought that it was to the interests of the Maxim-Weston Company to take up that position. Although electric lighting had made more rapid strides within the last three years than any branch of practical science, yet at the same time from certain standpoints it must be admitted that the enterprise was still more or less in its infancy. That being so it was necessary that their Company should keep in the van as to their patents, which necessitated continued outlay. With regard to that, however, he might say that the expenditure in connection with experiments, and plant consumed in those experiments, which had been added to their patents or stock sheets, had been as nearly as possible the same as they had spent in connection with the improvements which had been effected. They had not charged a penny for new patents or improvements on existing patents beyond the actual outlay, and though he did not wish to draw any invidious comparisons between their own and other companies, he thought he might point out that in the past year another company for the improvements they had made had added £14,000 to their patents. Last year the amount added by the Maxim Company had been under £1,400, although during the year they had designed and carried out satisfactorily to completion a new arc lamp, which he considered, and which he thought most of the shareholders would consider if they saw it, one of the handsomest and one of the most efficient lamps in the market, as well as other improvements in their dynamos and general appliances. There was another point in connection with electric lighting plant, namely, that of price. During the past year—he believed he was as nearly accurate as it was possible to be in a general statement—the turn out of plant was double that of the previous year, although the value obtained from it was not more than 20 or 25 per cent. in excess of the amount realised on the sales of the previous year. They had in many cases to meet the market, and while they had refused a great deal of business which they considered risky, they had tried to meet large customers throughout the country in the matter of prices, a proceeding which he considered advisable under the circumstances. He thought he might safely say that the Company had now something like 100 firms or companies as customers, the most distinguished in the various departments of business in which they were engaged in this country and throughout the colonies. They had also, through the favour of the American Company, been in negotiation with several European countries, and had appointed important agents, who in some cases had secured Government contracts. In the first paragraph of the report they stated that "a large number of orders since received were not in time to be included in the accounts for the past year." They could now look at those orders as closed business, amounting in the aggregate to what they had been able to carry out in the past year. They would have liked to include those orders in the past year's accounts, so as to have shown a better statement, and he had fully anticipated when he last addressed them that they would be able to pay the same dividend for the past year as for the previous year; but he would remind them that in connection with important contracts very long delays took place. For example, they had a Government contract for £6,000 or £7,000, which had been in negotiation for no less a period than eighteen months. It was very difficult, in doing a large business, to carry it out within a period so as to bring it within a given year. With respect to concessions, the Company did form one company in Lancashire, which, however, was unsuccessful in its operations, and they had bought back the rights for Lancashire for a nominal sum, taking back the plant, the concession, &c. That had increased the patents this year by £1,900, a sum which ought, in fact, to have been written up in the previous year's accounts. During the year under review they had done business in Lancashire to an amount between £4,000 and £5,000, and he was very happy to say that, forestalling the probable passing of the amendment of the Bill of 1882, they were now in negotiation with corporations, local bodies, and others throughout the country—negotiations which he had very good reason to hope would result in business; and he might say, as resulting from trials and tests which had been made in those places, that several other corporations with whom they had been in negotiation had intimated to them that they would do nothing in the way of electric lighting till one or other of the places indicated had decided, and that if the Maxim Company's plant were adopted there, they also would adopt the system. It was, perhaps, needless for him to say that in the event of one large corporation taking up their system it would represent a sum three times in excess of the business that they had yet been able to do in any one year. He thought they had so far established the superiority of their patents. They possessed now a complete arc and incandescent system; they had two incandescent dynamos, one arc dynamo, an improved arc dynamo, an arc lamp, and a new arc lamp designed by themselves last year. They were constantly receiving new patents from America, but they were not dependent on America, and in fact they were doing everything they could to make themselves independent of the American Company. The American Company had met them most handsomely in the matter of price, and, he believed, had reduced the price for the plant they were getting from them to an amount constituting a small percentage on the manufacturing cost to them. But still it was undeniable that America was very far behind this country in the matter of price—a fact due to their system of protection. Having gone into the matter closely, he thought he might say that America was at a disadvantage compared with this country of 30 per cent. in prices all round. The shareholders would therefore see that if the Company could manufacture the plant they required at an advantage of 30 per cent., they might occupy a very different position to that which they were now in. At the same time, it was very desirable to maintain their friendly relations with America, where there was a large staff and something like £5,000,000 of capital invested. They were constantly making improvements which were very vital to the Company, and it was therefore their object to maintain their connection with that country as long as it was not too detrimental to them in regard to the matter of price. He believed he had explained the position in regard to the Lancashire Company, and he might add that he had every hope throughout Lancashire, Cheshire, and North Wales, of doing five times the amount of business in the coming year compared with last year, provided that the Bill referred to became law and freed them from the existing suicidal legislation which was introduced in 1882. He was happy to say they had very influential and very able representatives throughout the country, but they had found the same difficulty that other companies had experienced in obtaining reliable men. They did not as a rule give salaries, but confined their operations to commission. He had referred to the first clause in the report, with respect to the orders which had been received since the 31st December. The next paragraph referred to the profit and loss, as shown in the balance-sheet. The third paragraph was the recommendation of a dividend, which no doubt would be regarded as the most satisfactory portion of his speech; and the fourth paragraph related to the issue during the past year of 50,000 shares to the shareholders at par value. That recommendation was made by a shareholder who he had since learned was, so to speak, a shareholder of yesterday, and he must confess that he regretted having agreed to the issue of the shares in that manner, as he had found that the great bulk of them had fallen into the hands of people who had thrown them on the market, thus depreciating the stock generally. He himself held 4,000 or 5,000 shares, and when the Company was struggling, and the shareholders would subscribe scarcely anything, he took between 16,000 or 17,000 shares, so that the present position was built up mainly on his own capital. If the shares, instead of having been issued as they had been issued, had been placed on the market, the Company would have obtained for them a premium of some £4,000. They had secured a factory, which he thought was fairly described in the report. They there stated that "they had secured on lease, within three miles of the Bank of England, a newly-built, spacious, and most suitable factory, at a comparatively low rental, which is probably the largest and finest electrical factory in Europe, and of such superficial area as will admit of any necessary extension." That in the past year had involved them in a rental of £180. The factory had been inspected by certain high officials connected with the Admiralty with a view of executing contracts, and the officials had entirely approved, and had handed in a most satisfactory report on the condition of their works, the plant, and the suitability of the manufactory for Government plant. The plant and machinery had been carefully valued, and due allowance had been made for depreciation. As to the installations which had been fitted up by them, they had had no complaints whatever except in regard to what he would call mixed installations, and they had now made a rule not to supply mixed installations. They would now supply only complete installations of the Maxim or Weston lamps, which they would be prepared to guarantee for a stated time. He then alluded to the report which had been received by the Directors from the auditor, Mr. Henry Dever. Having stated that the report was a *resumé* of the balance-sheet, he replied in detail to the various matters referred to, and entered into further explanations of various items in the balance-sheet. He said that they were engaged in no litigation of any kind, and that he hoped they would be able to maintain that position. They had now about 2,000 shareholders, and the Directors would be glad if they would advise them of any installations going on in their neighbourhood. They would be quite willing to pay the shareholders the 5 per cent. commission which they generally paid. The total expenses had been £5,371, an amount which he did not think could be considered excessive. They had had to sell their plant at a very low price, and he did not see any prospect of an improvement as long as persons would go on selling installations at a distinct loss, or selling worthless plant. As to the Company's new arc lamp, some of the shareholders might like to see it, and therefore he might state that the Company had just fitted up 22 of the lamps on the premises of Messrs. Gask and Co. (Limited), of Oxford-street. They had not been able to do as much business in London as they would like, but they thought it best only to take work which paid them. In conclusion, he moved the adoption of the report and balance-sheet.

Mr. LOUIS SWABY seconded the motion.

Mr. JACKSON expressed satisfaction at the Company in so short a time having been able to pay a dividend, and said that he was astounded at the statement that a shareholder had written asking the Directors to reduce their fees.

Mr. GRIFFITH said that Mr. Dever had contended that when they made any experiments, or took out any new patents, the expenses should fall on the current year's accounts, a view which the Chairman did not agree with. No doubt it was a question of policy, but he (the speaker) hoped that it was not the intention of the Directors to purchase any new patents. If they abstained from doing so the difficult question raised by Mr. Dever would be avoided. They were, he thought, indebted both to Mr. Dever and the Chairman for the full explanation which they had received of the accounts. They were certainly indebted to the Chairman for his able

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management of the affairs of the Company. He hoped they would continue to improve from year to year, and in that event, so far from reducing the Directors' fees, the shareholders would probably propose to increase them.

Mr. WARD said he could not help thinking that the paragraph in the report relating to the issue of shares should have been omitted. He thought it unfair to state to the shareholders in connection with that issue that the dividend they were going to receive was to be equal to 10 per cent. The Chairman had laid stress on the 5 per cent. dividend recommended to be paid on the capital of the Company; but it was not to be forgotten that the capital had been reduced from time to time until now the £1 shares stood at 5s. each. For his own part he failed to see how the sum which had been realised by the new shares had been invested. The item of patents showed an increase of £3,000, the stock of £4,000, but he could not see in the other items sufficient to make up the difference. As to Mr. Dever's remarks, he thought the suggestion of that gentleman important, that the expenses in connection with experiments and new patents should be put to current expenses. If that were not done there would be an indefinite increase to their capital. The expenses last year had shown an increase of £1,741, while the profit on sales had increased by £1,900. He contended that they ought to have had more information in the profit and loss account as to the turn over.

The CHAIRMAN, in reply, gave further information, to explain where the increase of capital had gone. A most exhaustive audit of their accounts had been made by Mr. Dever, and also by the Company's own professional accountant. They had therefore had a double audit as it were. When he become connected with the Company, the entire assets, patents, and everything would not have fetched £5,000. Since then they had added £25,000, making £30,000, while the present balance-sheet showed £80,000 of assets. He himself had nothing whatever to do with the bookkeeping of the Company, though he was Chairman and Managing Director. On the loan referred to in the balance-sheet they had received 10 per cent. interest. It had since been paid, and the money was now at the bank. As to the ownership of the glass globes belonging to the incandescent lamps, he would rather not enter into contentious matter. There had, unfortunately, been a large amount of litigation going on in America between what was the Maxim-Weston Company there (but their name was the United States Electric Company) and the Edison people. As for the Company, so long as they were not attacked he did not wish to attack anybody, although patents of theirs had been repeatedly infringed. He would like to see the companies engaged in the electric lighting enterprise working harmoniously together in opposition to the great vested interests they had to contend against. He did not agree with Mr. Griffith as to the improvements. At the last meeting he stated that one dynamo that had been working for a considerable time now produced sufficient current to keep seventy lamps running, whereas the same dynamo differently wound used to give them only thirty lamps. It must be perfectly obvious that the commercial value of a machine was immensely increased if they could run double the number of lamps with it. In that way they had been able to maintain very largely their prices. They had an excellent electrical manager and a new secretary who gave them all his time. They had a good staff, which they might have to increase, because he looked forward, as Lord Thurlow said the other day, to an immense increase of business. He would not change their patents for those of any other company in existence. If the last speaker (Mr. Ward) wanted information for his own private use he could obtain it by going to the office. He thought it was not to the interest of the Company that he (the chairman) should make public all the details connected with their business. He had, he believed, given them an exceptionally long statement respecting the affairs of the Company. He could not understand any gentleman who had any knowledge of bookkeeping arguing that £14,000 had been added to one side of the balance-sheet which was not shown on the other. How could the statement balance if that were not so?

Mr. JOHN NEWTON said he believed that the shareholders generally would not approve what the Chairman had said—that he would give any shareholder full information if he called at the office. In the case of the Telegraph Construction and Maintenance Company, which had entered on electric lighting in the last few years, that Company had never made a single statement in their reports to show the extent of the business done by them. The shareholders were quite satisfied, however, because they received 20 or 30 per cent. dividend. He thought that the shareholders of the Maxim-Weston Company would not agree to the Chairman making their position known in a manner which perhaps would prevent their getting a dividend. The letter which had been read from Mr. Dever he regarded as one of the most efficient testimonies that he had ever heard, showing as it did the way in which the shareholders' interests were protected by their auditors.

The CHAIRMAN, in answer to Mr. DISMORE, said that the actual number of shares issued was 56,000, and not 50,000, as was stated in the report, which was drafted before the additional number was issued. The fact was that a few of the shareholders who were a little late—and who had explained that they had bought their shares, as he himself had, at ¾ premium when the shares were £1 each—urged their hardships, and the Directors agreed to issue them the number of shares which increased the total issue to 56,000. He then put the motion, which was carried, and afterwards proposed the declaration of a dividend of 5 per cent.

Mr. SWABY seconded the motion, which was carried unanimously.

On the motion of Mr. HODGE, seconded by Mr. GEO. RUSSELL, Mr. Watt and Mr. John Brown were re-elected Directors of the Company; and, on the motion of Mr. NEWTON, seconded by Mr. WARD, Mr. Henry Dever, F.C.A., was re-elected auditor.

Mr. WAINWRIGHT then proposed, and Mr. DISMORE seconded, a resolution to the effect that the remuneration of the Directors should be the same as in the previous year—£500.

Mr. WARD, in proposing a vote of thanks to the Chairman, stated that he had had no personal feeling in the remarks which he had made. He believed that the Chairman was doing his best for the Company.

Mr. NEWTON seconded the motion, which was carried unanimously, and the proceedings then terminated.

CITY NOTES, &c.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of February was 3,821, estimated to produce £3,000, against £3,402 messages, producing £2,771 in the corresponding month of last year. The traffic receipts for the month of November, estimated at £2,555, realised £2,580.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company are as follows:—February £19,200, 1st January to 28th February £39,600, corresponding months in 1886 £38,680, and for the corresponding month in 1885 £20,800.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ended 28th February amounted to £4,625.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 11th March were £2,947, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended February 28th are £2,921, as compared with £2,490 in the corresponding period of 1886. The November receipts, estimated at £4,347, realised £4,485.

DISSOLUTION OF PARTNERSHIP.—Messrs. Swete and Main inform us that, owing to the continued ill-health of Mr. Main, the partnership existing between them has been dissolved, but the business of the firm will be carried on by Mr. Swete under the same style and title as heretofore.

REMOVAL.—We understand that Messrs. J. G. Statter and Co. have removed the chief part of their business to the Alliance Engineering Works, West Drayton, near London, where, from their having both brass and iron foundries on the premises, and more space, they will have greater facilities for carrying on their present business. The London office is at 49, Finsbury-pavement. For the present they intend to keep on Middleton-road Works for lighting work.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. March 9.		Business Done Week Ending March 9. Highest.	Lowest.
Anglo-American	32,	33	—	—
Do. Preferred	53,	54½	54	52¾
Do. Deferred	11½,	12½	11¾	11½
Brazilian Submarine	10¾,	11	11	10¾
Cuba	11¼,	11¾	11¾	11½
Do. Preference	18,	19	—	—
Direct Spanish	2,	2½	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	8½,	8¾	8½	8
Eastern Telegraph	10¼,	10½	10 9-16	10 5-16
Do. 6 per Cent. Preference	13,	14	13⅝	—
Do. 5 per Cent. Debentures, 1899	104,	107	106	105½
Eastern Extension	11⅛,	11⅜	11⅜	11¼
German Union	8¾,	9¼	9 3-16	8⅞
Globe Telegraph and Trust	4¾,	5	4⅞	4¾
Do. Preference	11¾,	12	11 15-16	11⅝
Great Northern	13¼,	13½	13⅜	13¼
Indo-European	34½,	35½	—	—
Reuter's	6¾,	7¼	—	—
Submarine	185,	195	188	— xd.
West India and Panama	⅝,	⅞	¾	11-16
Do. 1st Preference	8¾,	9¼	9⅛	8⅞
Western Brazilian	7¾,	8	7 15-16	7⅞
Western Union 7 per Cent. 1st Mortgage	123,	127	123	—
Do. 6 per Cent. Sterling Bonds	100,	102	—	— xd.

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	⅞	⅞	—
Oriental	3-16,	5-16	—	—
United Telephone	12,	12½	12¾	12 9-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	2⅝	—
Do. (fully paid)	3¾,	4¼	4¼	4
Swan	1½,	1¾	1⅝	1⅜
Maxim Weston	3-16,	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	37½,	38½	38½	37½
India Rubber, Gutta Percha, and Telegraph Works	21½,	22½	22¼	21⅞ xd.

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NOTES.

THE ELECTRIC APPARATUS COMPANY.—This company sends us a copy of their price list, which will be found to contain a very complete catalogue of electrical requirements.

FORTHCOMING TREATISE ON SECONDARY BATTERIES.—We learn that Prof. Silvanus Thompson has in hand "A Treatise on Secondary Batteries," which will be published by Messrs. Spon.

LUBECK.—We recently noted the establishment of a central lighting station in this town by the well-known firm of Schukert and Co. We hear that the number of subscribers already exceeds 2,000.

THE LIGHTING OF AN EDINBURGH COLLEGE.—The Building Committee of the Heriot-Watt Trust have recommended the Governors to adopt the electric light for the new college buildings now in course of erection.

BOLTON.—The town of Bolton has decided to commemorate the Queen's Jubilee by the foundation and endowment of a technical and scientific college. A somewhat similar movement has been set on foot at Southampton.

MADRAS.—The offices of the Eastern Extension Telegraph Company at Madras are now lit with 7 Edison-Swan 10 candle-power incandescent lamps, from a Holmes-Burke patent primary battery, supplied by the firm of Johnson and Phillips, London.

BERCHEM, HOLLAND.—The town of Berchem, near Antwerp, is to be supplied with an arc lighting plant for street illumination by the Société Industrielle d'Electricité, of Brussels. The same company is also lighting the neighbouring village of Borgerhout.

MERCURY CONTACTS.—Is there any record of the completing of an electrical circuit by means of the expansion of mercury in a thermometer before the patent of A. Bain in 1844, who employed this means to indicate the temperature in the holds of ships?

THE SNOWSTORM.—So far as we have yet learnt the snowstorm has not on this occasion inflicted any serious injury to the overhead wires in the neighbourhood of London, but in the neighbourhood of Bristol it is stated that telegraphic and telephonic communication has been again almost entirely suspended.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—A meeting of this society will be held at the Institute of Civil Engineers, Great George-street, Westminster, on Thursday, March 24th, at 8 p.m., when a paper will be read "On the Resistance of Faults in Submarine Cables," by Mr. A. E. Kennelly, Associate.

TENDERS REQUIRED FOR TELEGRAPH MATERIAL.—The Manchester, Sheffield, and Lincolnshire Railway Company advertise for tenders for the supply of telegraph material. Specifications and forms of tender may be obtained from Mr. E. Ross, secretary, London-road Station, Manchester, and are to be returned by the 30th inst.

ELECTRIC LIGHTING AT MARLBOROUGH HOUSE.—The Indian Room at Marlborough House was again lit by the Electrical Power Storage Company on the 10th inst., the occasion being the anniversary of the wedding of their Royal Highnesses the Prince and Princess of Wales. The work was undertaken at short notice, but a few hours before the light was required.

"A CENTURY OF ELECTRICITY."—It is stated that Prof. Mendenhall has just completed an important historical treatise on electricity. His work will aim at giving a complete record of the discoveries, inventions, and appliances of the past hundred years. American and English editions of the book are to be issued simultaneously, under the title of "A Century of Electricity."

EFFECTS OF AN ELECTRICAL CURRENT ON IRON WHEN COOLING.—Lieutenant Zalinsky, the inventor of the dynamite gun and submarine torpedo boat, it is reported, on the authority of the *New York Herald*, has been making some preliminary tests which have shown that iron cooled while a strong current of electricity was passing through it was increased fully one-half in tensile strength and ductility.

EXECUTION BY ELECTRICITY.—The last Legislature of New York appointed a committee to examine into the most expedient method of inflicting the death penalty in cases of murder in the first degree, and to report on the subject to the present Legislature, whether by Bill or otherwise. It is stated that the committee agreed to recommend the abandonment of hanging and the substitution of an electric method.

THE UNITED TELEPHONE COMPANY.—We understand that the delay in effecting the repairs to the lines of this company, which were destroyed in the snowstorm at Christmas, has largely arisen from the refusal of way-leaves which has (not perhaps unnaturally) taken place. This is more especially the case in the West End, and at Westminster, in particular, it is stated that "the exorbitant demand by one company necessitated heavy alterations in poles and wires."

TELEGRAPHS IN CHINA.—It is stated that the Marquis Tseng, who has lately returned to China from his long residence as representative of that empire in London, has signalised his arrival in his native country by his earnest endeavours to have a line of telegraph completed between Pekin and the most important trade centres in China. He has submitted plans prepared by competent men to the Imperial Government, and it is expected that these will shortly be accepted.

INTERNATIONAL EXHIBITION AT BARCELONA.—An international exhibition is announced at Barcelona, which will have a section devoted to electrical exhibits. The exhibition is to be opened the 15th of September next, and will remain open for six or eight months. The Spanish railway companies had announced a reduction of 50 per cent. on their ordinary tariff in connection with this exhibition, and similar reductions will be given, according to *L'Elletricita*, by most of the shipping companies.

TONQUIN.—The *Standard* states that a telegram from M. Constans, French Minister at Pekin, informs the Minister for Foreign Affairs that the Chinese Government is disposed to authorise the junction of the Chinese telegraph lines with the French line of telegraph wires in Tonquin. This connecting of the two lines of telegraph will form the object of a special convention, the details of which will be settled between M. Riestvelhueber, French Consul at Tien-Tsin, and the Director of the Chinese Telegraph at Tchefou.

ST. PETERSBURG.—The Municipal Council of St. Petersburg has, after long discussion, decided in favour of continuing the electric lighting of the Novsky and of the Grande Moskaia. The contract has been let to the firm of Siemens and Halske, who have received a concession for twelve years for the electric lighting of private houses, and also the right of establishing four electric stations at a rent of £80 each. In consideration of these privileges they charge for the public lighting of the two streets above mentioned 17 cop. (about 4d.) per hour per light.

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THE BELL TELEPHONE IN AUSTRIA.—The Vienna *Electro-Techniker* states that "the Consolidated Telephone Construction and Maintenance Company and the Telephone Company of Austria have met with a severe rebuff at the Courts in Austria. The first named company had lodged an action for annulment of the patent of Prof. Alexander Graham Bell, in order to protect its Austrian establishment. This action, like many others, has now been dismissed with costs by the Austrian judicial authorities. As in England, the Bell patent remains consequently in force in the dominions of the Austrian monarchy, and the Telephone Company of Austria, being infringers of that patent, will have to reckon with the patent owners.'

NEWSPAPERS AND THE PROGRESS OF TELEGRAPHY.—Some interesting statistics of the progress of telegraphing are given in a work by Mr. William Hunt, of Hull, entitled "Then and Now; or, Fifty Years of Newspaper Life." In 1870, when the telegraph wires were transferred to the Government, only 168 newspapers received the limited news supply of the old companies; while in 1885 no less than 578 papers were receiving telegraphic services from the two news associations, and during 1886 the number of words telegraphed in press messages is estimated to have been no less than 578,382,655. Mr. Hunt ascribes this vast increase to the healthy competition now in news supplies as compared with the monopolies of the old telegraph companies.

"ONE HUNDRED GUINEAS REWARD."—On Wednesday, at the Royal Aquarium, a council meeting of the Balloon Society of Great Britain was held, under the presidency of Captain Parry, R.N., when Captain Wilson proposed the following resolution:—"That the Society's gold Jubilee medal and one hundred guineas be offered for a discovery rendering electricity economically applicable in the shape of heat, light, chemical action, mechanical power, transmission of message, or treatment of disease." The speaker remarked that eight days before the Queen ascended the throne Prof. Wheatstone and Sir James Fothergill Cooke took out a patent for the transmission of messages by means of the electric telegraph. The resolution was unanimously carried.

THE NEW YORK WIRE CONDUITS.—The affairs of the New York Subway Commission have got into a very tangled condition. Several Bills have been brought before the New York Legislature with a view of clearing up the legal difficulties to which the action of the Commission has given rise; but, as they are in general promoted by opposing interests and propose contradictory solutions, it is probable that the question will take some time to settle. In the meanwhile the work is at a standstill. It may easily happen, however, that this temporary stoppage will, in the long run, prove to be beneficial, inasmuch as it will afford time for testing the behaviour of the lengths already laid. The accounts received have not up to the present been perfectly satisfactory on this point.

THE TELEPHONE AS A SOURCE OF INFECTION.—At a meeting of the Caucasian Medical Society, reported in the *British Medical Journal*, Dr. A. P. Astvatzaturoff, of Tiflis, drew attention to the danger of infection arising from the promiscuous use of the mouthpieces of public telephones. To prevent any accident of the kind, he recommends that the mouthpiece should be disinfected every time after, or, still better, before it is used. In other words, some disinfectant fluid should be kept at every telephone station, and the speaker should, first of all, dip the mouthpiece into the fluid, and then wipe it with a clean towel. The suggestion seems to have been made in perfect good faith; but it is surely not a little ridiculous, and we feel some surprise that the *British Medical Journal* did not say as much.

ELECTRICAL COMMUNICATION WITH LIGHTSHIPS.—A meeting of the Committee on Electrical Communication between Lightships and the Shore was held at the Board of Trade on the 10th inst. The Earl of Crawford presided, and there were present Colonel King-Harman, M.P.; Sir E. Birkbeck, M.P.; Mr. Sutherland, M.P.; Sir George Nares, Colonel Hozier, Mr. Cecil Trevor, and Captain Owen. Mr. Mattersley, Superintendent of the Trinity Board, gave evidence in favour of the use of light vessels of the larger type, and instanced several cases of bad wrecks which might have been avoided if there had been electrical communication. Mr. Bales, of Ramsgate, for many years in the employment of the Trinity Board, was examined in reference to the Goodwin Sands; and Mr. Fish, who has been for seventeen years coxswain of the lifeboat at Ramsgate, spoke in favour of improved means of communication with light vessels.

TELEPHONE SERVICE TO CROYDON.—In this year of grace, 1887, when in most of the inhabited parts of the globe telephonic communication between adjacent market towns is the rule rather than the exception, the inhabitants of Croydon have at last been accorded the privilege of a telephone line to the metropolis. The gigantic character of this undertaking will be appreciated when we mention that the line is no less than ten miles in length, and runs nearly the whole distance alongside the Brighton and South Coast Railway. The representative of an evening journal was last week accorded the privilege of talking over the new line, and "found the communication everything that could be desired." We tender our sincere congratulations to the United Telephone Company upon this truly noteworthy achievement, and trust that its success may be sufficiently marked to induce them within the next few years to extend their operations in other suburban localities.

IMPROVEMENTS IN INCANDESCENT LAMPS.—According to a paper in the *Electrotechnische Zeitschrift* for February, incandescent lamps, with long fine carbon fibres, are very liable to damage, owing to the elasticity of the fibre causing it to vibrate considerably when the lamp is shaken, which frequently results in the fibre being broken; long fine fibres are also very liable to warp, causing injury to the glass. This the Cruto Company has remedied by fusing small hooks of platinum wire into the glass to support the fibre and keep it in its place. The same method has also been adopted by Siemens and Halske. Hitherto the only method in use for obviating the dazzling effect of incandescent lamps has been the use of ground glass. Siemens and Halske have recently attained the same end in a very inexpensive manner by dipping the lamps in a thin semi-transparent varnish. The lamps so treated can only be distinguished by close inspection from lamps in which ground glass is used.

ELECTRIC LIGHTING OF TRAINS.—Since the recent distressing railway accidents in the United States, in which the *débris* was set on fire, there has been a great outcry for an improved method of lighting and warming the carriages. It may be regarded as certain that the American electricians will do their utmost to introduce some practical method of solving the problem by electrical means. We do not see any reason why the arrangements already in use on a limited scale in this country should not receive an extended application in America. American companies and inventors have already reaped a fair harvest in this country, and we should be very glad to see the tables turned. One suggestion from the other side which has already received some attention is that of driving the

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dynamo in the guard's van by means of compressed air, which is stored in a reservoir by the engine while running; the reservoir holds sufficient to run the machine during the stoppage of the train. The system is, of course, a wasteful one.

EXPERIMENTS WITH THE "PHONOPORE."—It is stated that successful experiments have been carried out upon the South-Eastern Railway with Mr. Langdon-Davies' so-called "Phonopore." (O, Mr. Langdon-Davies, *why* did you choose such a *very* dreadful name ?) The great advantage claimed for this apparatus is that no interference with ordinary working over the same line is necessary, so that the circuits can be worked either *simplex*, *duplex*, or *diplex*. The recent experiments were carried out upon the railway telegraph lines between London Bridge and Folkestone. Messages were sent and received simultaneously at each station (duplex working), and two messages were also sent simultaneously from one station (diplex working). The arrangements are more simple than either of the usual duplex methods, and do not require adjustment when once set up. The phonopore may also be applied to a line already duplexed in the ordinary way.

METHOD OF SHOWING THE MOVEMENTS OF PARAMAGNETIC AND DIAMAGNETIC LIQUIDS.—Prof. A. Ricco describes in a letter to *L'Elltricita* a novel and striking lecture experiment, showing the behaviour of diamagnetic and paramagnetic liquids in the magnetic field. A beam of light from a candle, after passing through a convex lens, is reflected from the level surface of the liquid placed between the pole of an electromagnet, and the image of the flame is focussed on a screen. In the case of a neutral liquid the image is unaffected by the excitation of the electromagnet, but if it be either diamagnetic or paramagnetic the image becomes distorted and confused. If the liquid be paramagnetic the clearness of the image can be restored by moving either the candle or the screen nearer to the lens, or by removing the lens; the resulting image will be elongated, showing that the surface of the liquid must be cylindrical concave. In the case of a diamagnetic liquid, on the other hand, either the candle or the lens must be moved away from the screen, or the lens must be replaced by one less convex, which shows that the surface of the liquid is now convex.

THE BRITISH ASSOCIATION.—At a committee meeting held recently at 22, Albemarle-street, the principal officers for the Manchester meeting of the British Association, to begin on August 31st, were selected. The President will be Sir Henry Roscoe, M.P., F.R.S. The presidents of the various sections will be as follows:—Section A, Mathematics and Physics, Sir Robert S. Ball, Astronomer Royal for Ireland; B, Chemistry, Dr. Edward Schunck, F.R.S.; C, Geology, Dr. Henry Woodward, F.R.S.; D, Biology, Prof. A. Newton, F.R.S.; E, Geography, General Sir Charles Warren, R.E., G.C.M.G.; F, Economic Science, Dr. Robert Giffen; G, Mechanical Science, Prof. Osborne Reynolds, F.R S. For Section H, Anthropology, a president has not yet been obtained. The Manchester meeting promises to be one of the most brilliant, socially at least, ever held. A very large sum has already been subscribed, and the excursions and other entertainments will be on an unusually liberal scale. One of the public lectures will be given by Prof. H. B. Dixon, on "The Rate of Explosions in Gases;" the lecture to the "operative classes" will be by Prof. George Forbes.

AMERICAN CRITICISM ON KAPP'S PREDETERMINATION OF DYNAMO CHARACTERISTICS.—The *Electrical World* of New York contains an article designed to show that Mr. Kapp has been guilty of a serious oversight in his recent work in relation to dynamo characteristics. An error has been discovered in the expression relating to the calculation of the E.M.F. which is generated in a given armature, running at a known speed, when the number of lines of force passing through the armature core is also known. The American critic having drawn a diagram of the situation, enters into a mathematical discussion tending to show that the calculated value of E should be twice as great as that given by Kapp. If, however, we accept the corrected formula as applicable to machines of American construction, then, by a simple process of reasoning backwards from this point, it can be shown that in these machines the whole of the armature coils must be connected in series. In this country, on the contrary, the armature coils invariably afford (at least) two parallel circuits between the brushes; so that as far as English practice is concerned we venture to think that Kapp's formulæ may for the present continue to be used without hesitation.

TELEGRAPH STATISTICS.—The new issue of "The Statesman's Year Book" (Macmillan) gives the following statistics relating to the telegraphs of the world:—

States.	English miles.	States.	English miles.
Belgium	5,711	Austria-Hungary	35,086
France	61,286	Servia	1,736
Switzerland	4,349	Portugal	3,111
Great Britain & Ireland	30,276	Roumania	3,199
Germany	51,869	Bulgaria	1,521
Netherlands	2,938	Spain	11,158
Turkey	14,618	Norway	4,591
Denmark	2,447	Russia (and Finland)	68,611
Greece	4,054	Sweden	5,361
Italy	18,359		
Total for Europe, 328,281.			
Cochin China	1,444	Dutch East Indies	3,592
Ceylon	1,158	Persia	3,209
Japan	5,583	Tonking	159
British India	25,380	Straits Settlements	121
Philippines	718	China	944
Asia, total for the above countries, 42,308.			
Salvador	1,260	Uruguay	1,032
Cuba	2,811	Canada	20,466
United States	164,954	Columbia	2,357
Guatemale	1,816	Peru	1,382
Honduras	1,349	Venezuela	1,145
Nicaragua	1,306	British Guiana	264
Mexico	19,430	Brazil	6,432
Chili	7,625	Ecuador	400
Argentine Republic	12,479	Paraguay	45
Costa Rica	450	Bolivia	180
America, total for the above countries, 247,183.			
Réunion	76	Egypt	5,858
Tunis	1,874	Orange Free State	560
Algeria	3,661	Transvaal	120
Cape Colony	4,244	Mozambique	53
Senegambia	1,535	Angola	219
Africa, total for above countries, 18,220.			
Tasmania	1,635	Australia	30,000
New Zealand	4,463		
Total for Australia, 36,098.			

EARTHQUAKES AND EARTH CURRENTS AT TOKIO.—Prof. Milne recently delivered a lecture before the Rigaku Kyokai, or Science Society, "On Pre-scientific Theories of the Cause of Earthquakes," in which he mentioned that the theory of electrical discharges was advocated in 1760 by Dr. Stukeley, as well as by Percival and Priestly. This view is strongly held in California at the present day, where it it is believed that the network of railway lines protected the country against any dangerous accumulation of electricity. But Prof. Milne showed that in Japan at least the laying down of rails had no such effect. He thought that the electric phenomena which sometimes attended earthquakes were their

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consequence, not their cause. He had himself experimented with dynamite placed in a hole; an earthplate was fixed about thirty yards away from the dynamite, and from it a wire was carried some distance to another earthplate. When the dynamite charge was exploded there was certainly a current produced, as was indicated by a strong deflection of the galvanometer needle at the other end of the wire. He attributed this to chemical action. When the ground was shaken there was always a greater or less action by increase or decrease of pressure in connection with the earthplate. Earth currents unquestionably accompany earthquakes, but, as has been said, they appear to be the consequence, not the cause, of the latter.

CONVERSAZIONE AT THE CITY AND GUILDS OF LONDON CENTRAL INSTITUTE.—On Wednesday evening last a *conversazione* was held at the City and Guilds of London Central Institute, Exhibition-road, S.W. The guests were received in the library by the Earl of Selborne (Chairman of the Council) and Lady Waldegrave, Sir Sydney Waterlow (treasurer), and Lady Waterlow, and by Mr. H. Saunders, Q.C. (Chairman of the Executive Committee), and Mrs. Saunders. A large number of invitations had been issued, and nearly the whole of the extensive building was thrown open to the visitors, and objects of interest either in science or in art were displayed in every room. During the evening a series of demonstrations were given in the various lecture rooms, the following being the programme: (1) a demonstration by Prof. Ayrton, F.R.S., in the Physics and Engineering Lecture Theatre; *Subject*—Mechanical Production of Electric Currents in 1837 and 1887. (2) a demonstration by Mr. J. Sawyer, managing director of the Autotype Company, in the Chemistry Lecture Theatre; *Subject*—The Autotype Process. At 10:30 p.m., (1) a demonstration by Prof. Armstrong, F.R.S., in the Chemistry Lecture Theatre; *Subject*—Production of Madder Colours and Indigo from Coal. (2) a demonstration by Prof. Fleming, Examiner to the Institution in Electrical Engineering, in the Physics Theatre; *Subject*—Photographs of the Moon, exhibited with the lime-light lantern. At 11:30 p.m., (1) a demonstration by Prof. Roberts-Austen, F.R.S., Examiner to the Institute in Iron and Steel Manufacture, in the Physics Lecture Theatre; *Subject*—Methods used by the Japanese in Art Metal Work. At intervals during the evening experiments were also made by Prof. Unwin, F.R.S., Dean of the Institution, with the 100-ton testing machine, and with the experimental steam engine in the Engineering Laboratory. The musical arrangements were also carried out upon an extensive scale, a popular ballad concert, with orchestral accompaniment, being given under the direction of Mr. H. Thomas; while in another portion of the building a selection of glees and madrigals was sung at intervals under the direction of Mr. E. Plater. It may be added that amongst the electricians present, special interest was taken in Prof. Ayrton's new and remarkable instrument for the direct measurement of the coefficient of self-induction of a coil. Speaking from personal observation we should say that the gathering may be considered one of the most successful and enjoyable of the season.

ELECTRIC LAUNCHES.—At a recent meeting of the Société Français de Physique, M. Trouvé presented the society with a motor and battery such as he employs in his electric launches. The motor consists essentially of a Gramme ring, running between the poles of an annular magnet. At a speed of 2,400 revolutions it is stated that the output reaches the high value of 1 horse-power per 15 kilogrammes of total weight. The actual output, however, is not given; but probably it does not exceed 1 horse-power. For larger sizes it may be anticipated that the ratio of output to weight would at first diminish rapidly. As it stands, however, the above figures are considerably better than the latest English practice. M. Trouvé also continues to obtain satisfactory results from his bichromate batteries. He uses a liquid composed of 125 grammes of bichromate of potash dissolved to one litre of water, with the addition of one-fourth the volume of sulphuric acid. The E.M.F. is at first 2·1 volts, and does not fall below 1·9 volt The size of the cells is not given, but it is stated that their internal resistance is at first 0·001 ohm, rising after some time to 0·07 or 0·08. (We are inclined to think that a decimal point has been misplaced in the first of these values.) The current required for the motor is about 20 amperes, and the battery supplies this with ease. It is a little surprising, perhaps, to find that the possibility is still entertained of using zinc batteries on a scale adequate to the requirements of modern electrical engineering. M. Trouvé, however, does not intend to rest content with his present achievements, but is bent on effecting a complete revolution in our present methods of navigation. The paper from which we have quoted concludes in the following terms:—"The results obtained by M. Trouvé permit us to foresee in the near future the adoption upon a large scale of electric navigation for vessels of all dimensions. M. Trouvé is enabled to quote figures which upon this point may be taken as conclusive. We all know that no vessel at present built can steam more than 5,000 kilometres without recoaling; by electricity we can easily do double the distance. The motor and battery together will not weigh more than 200 kilogrammes per horse-power, and the consumption of zinc and of liquid will not exceed 2 kilogrammes (4·4lb.) per horse-power hour." This argument does not appear to us, however, to be entirely convincing, even if we take it upon its own ground and consider only the weight of material consumed. M. Trouvé must surely be aware that modern marine engines do a horse-power hour for a consumption of less than 2lb. of fuel.

THE TELEPHONE IN INDIA.—Mr. Killingworth Hedges, writing in *Industries*, gives the following account of the present position of the telephone in India:—"The telephone interests are controlled throughout the Indian Empire by the Oriental Telephone Company, who have started subsidiary companies in Bombay, Calcutta, Madras, and Kurrachee. The Bombay Telephone Company, which may be taken as representative, commenced operations about four years ago, and has 350 subscribers, who pay different subscriptions; that for merchants, banks, and mills being £15; for shopkeepers, £12; and for private use, £7. 15s. per annum. There are also eight call boxes, on the exchange system, for which the charge for each conversation is two annas, or about 2¼d., taking the exchange at 1s. 6d. for the rupee. The police and fire stations are also in communication, and all the exchanges are open day and night, Sundays included. The system employed is the Blake transmitter and Gower-Bell telephone, with magneto call bells instead of batteries, which would require constant attention in the hot season. The wires are principally of phosphor bronze, 17 B.W.G., as iron is found to decay; they are run on insulators supported by brackets, which are fixed to the walls of the houses, at a sufficient height from the street to allow of a loaded elephant passing under. This plan was necessitated on account of the flimsy character of the roofs, which would not bear a pole and wires. The lines within the native town have to be watched by a patrol, whose duty is to remove obstructions, as the wires offer advantages for drying clothes which the people appreciate, and in spite of constant inspection, at times the working is stopped by similar obstacles. Earth returns are used throughout the system, and appear to be satisfactory; there is

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little induction or leakage. At Rangoon, however, it was found impossible to converse until fluid insulators were employed to prevent the leakage. In Bombay female operators attend to the calls, whilst boys are employed in the other towns. The number of calls at Bombay averages thirty-four per subscriber per week; at Calcutta they are twenty per week, and the difference is accounted for by the greater number of native subscribers at the former city, who use the telephone on every possible occasion, and it is principally for them that the night service is maintained. The excessive talkativeness of the natives is supposed to be the reason why the Government object to the introduction of the telephone in the departmental offices, although, in a large city like Bombay, much time and expense would be saved by easier intercommunication."

MAGNETIC EQUIPOTENTIAL CURVES.—In the *Journal de Physique*, M. E. Colardeau describes some singular results obtained by the use of the sesquioxide of iron and other substances of low magnetic permeability (such as cobalt or nickel oxides) for the delineation of the magnetic field. When one of these substances, in a state of very fine division, is strewn over a thin plate *of iron*, which is placed in a tolerably powerful field, it is found that the particles arrange themselves in curves which are at all points orthogonal to the direction of the lines of force. These curves are therefore equipotential lines. For instance, if two poles of opposite name face one another, the lines of force, except near the edges, pass straight across from pole. But the lines traced by the sesquioxide between the poles lie in straight lines *parallel* to the polar faces, and in the outer portions of the field are everywhere perpendicular to the tangents to the lines of force. This effect is not produced with powders whose magnetic permeability is inappreciable, nor is it produced by diamagnetics. It is also necessary that the particles be strewn on an iron plate. The explanation given by M. Colardeau is the following:—We know that a line of force is like a stretched elastic thread, and tends always to shorten its length. If a strongly magnetic powder, such as iron filings, is disposed along a line of force, then the polar attraction of the particles for one another is strong enough to hold the chain together when once fully formed. But if the particles be not themselves strongly magnetic, then the attraction of the field upon them is more powerful than their attraction upon one another, and consequently the shortening tendency of the lines is able to come into play. This case may be illustrated by that of two bodies of not very great mass, whose attraction for one another is negligible in comparison with that of the earth upon either. The consequence is that a particle or row of particles considered as lying along a line of force have no special tendency to maintain their positions, and have little or no mutual adherence. When, however, in order to complete the formation, we give to the field a succession of slight mechanical shocks, the tendency of the particles is to travel in such a direction as will shorten the line of force on which they lie—that is, the particles (or some of them) travel along equipotential lines; and thus, the powder being very fine, many particles are left behind and mark out the path. By the employment of the magnetic oxide of iron, which has a higher magnetic permeability than the sesquioxide, and by suspending it in a solution of gum-lac in alcohol, spread thinly over the field, M. Colardeau has succeeded in obtaining some very curious figures, in which the two sets of lines are superposed. In these the equipotential lines are by far the more clearly defined, but the lines of force are also plainly visible.

ELECTROLYTIC BLEACHING.—At an ordinary monthly meeting of the London Section of the Society of Chemical Industry, held in the rooms of the Chemical Society on Monday evening, Mr. David Howard, F.C.S., president, in the chair, a paper was read by Mr. C. F. Cross on "M. Hermite's Method of Electrolytic Bleaching." In this paper, which was based on experiments by Mr. E. J. Bevan and Mr. Cross, the old bleaching process was compared with M. Hermite's method, especially as regards efficiency and expense. In view of the threatened extinction of the Leblanc process for the manufacture of alkali, and the consequent cessation of a supply of hydrochloric acid obtained as a by-product, the question of the future supply of bleaching powder must be faced ere long. The price of this bleaching agent will tend to rise as the Leblanc process falls, and so bleachers will have to consider whether they shall continue to use this bleaching agent, or others of a like nature, or turn to entirely new methods, such as that of M. Hermite's. The only bleaching agents other than chlorinated lime which may be used are permanganate of potash and hydrogen peroxide. The relative efficiency of these agents, taking available oxygen as the basis, is as follows:—Chlorinated lime, 7·5 per cent.; potassium permanganate, 15·7 per cent.; and hydrogen peroxide (10 vols.), 1·4 per cent. The first is in all respects the cheapest agent. After discussing the theories of bleaching by chlorinated lime, and showing that it is a process of oxidation, the authors proceeded to describe Hermite's method. It consists of splitting up alkaline chlorides, preferably magnesium chloride, in aqueous solution by means of electrolysis. The electrolytic decomposition of water was discussed, and in contrast with this the decomposition of magnesium chloride was referred to. It was shown that much hypochlorite was formed, as well as hydrogen and hydrogen peroxide; but the reactions are very complicated, and, for the sake of comparison, the authors had estimated the bleaching value of the electrolysed solution from its hypochlorite content. In practice, a solution containing 2½ per cent. of anhydrous magnesium chloride is used. It was shown by experiment that an electrolysed solution of this kind possessed greater bleaching properties than a solution of chlorinated lime of the same strength. The authors then proceeded in greater detail to discuss the relative efficiency of the two processes, and then summed up by an estimate of the relative cost. A 5 horse-power engine is capable, with a dynamo, of giving 100 kilos. of chlorine per hour, which is the equivalent of 6 cwt. of bleaching powder; but owing to technical difficulties the action of bleaching powder is proportionately diminished as the solution becomes weak, so that much of the bleach is lost, whereas the electrolysed solution may be obtained of constant and the same working power from the beginning. Thus, one of chlorine by the new system does as much work as two by the old. A 5 horse-power engine is capable of producing the equivalent of 1 ton of bleaching powder in twenty-four hours at a cost of £1. 10s., and the installation of special apparatus, such as dynamos, electrodes, baths, &c., for utilising the power of the engine, would be £1,500 (that is, £350 for each installation), or a cost of £1 per ton. There is very little loss; 5 per cent. of magnesium chloride, retained by the vegetable fibre, being the principal item. It will be seen, therefore, that this estimate is far below the present price of bleaching powder (about £8 or £9); and that Hermite's is a process which deserves the attention of manufacturers.—The President, in moving a vote of thanks to the authors, said that the communication was one of great importance in view of the precarious condition of the Leblanc process. He had watched the experimental bleaching on the lecture table, and viewing it closely from the chair, he was struck with the rapidity of the action of the electrolysed solution.

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

In designing any class of machinery a clear conception of the principles involved is essential to success, and the design and construction of dynamos forms no exception to this rule; hence before entering upon the practical application of electro-magnetics it will be necessary to glance briefly at the elements of our subject.

It is, of course, well known that a magnetic pole is surrounded by a "field of force" emanating in invisible lines

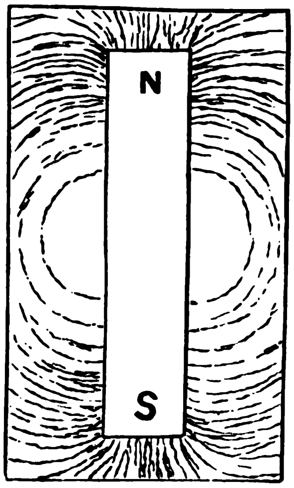

Fig. 1.

from its surface. The properties of these lines, and the principles of their propagation, are what we have to study in order to deal successfully with the construction of dynamos. One of the most important points to be grasped in connection with this part of the subject is this:—So far as we know at present there is no such thing in nature as a magnetic insulator, all kinds of matter being more or less permeable to magnetic force, and were it not for the fact that there is a distinction of the most pronounced kind between the permeability of iron and that of all other substances, magneto electric generating apparatus would be a physical impossibility.

The difference in the permeability or conducting power of iron and that of other materials is one of degree only; it is, however, so marked that for our purposes all matter may be divided into two classes, magnetic matter and non-magnetic matter. Practically speaking, iron is the only magnetic material; the magnetic properties of nickel, cobalt, and some few crystalline forms of other substances being so inferior as to be negligible. The permeability of all non-magnetics may also in the same sense be considered as equal.

The resistance which a substance offers to the passage of lines of force may be stated as the reciprocal of its permeability or conductivity. In non-magnetics this is found to be independent of the number of lines; iron, on the other hand, becomes saturated at a certain density of lines, which varies with the quality of the material.

The exact nature of the law governing the saturation of iron is not yet properly explained. Several theories and formulæ have been advanced, and have received the expansion or criticism of various scientists, but no practical method of dealing with this difficult point has appeared until quite recently, when a paper by Mr. Kapp was read at the Society of Telegraph-Engineers, "On the Predetermination of the Characteristic," in which the coefficient of saturation is taken as a tangent function of an angle representing the density of lines per unit of cross section, such a measure being adopted that the angle 90° denotes complete saturation. We shall show in due time the method of applying the above coefficient in practice.

A still more elaborate memoir, by Doctors J. and E. Hopkinson, was read at the Royal Society in May, some time in advance of Mr. Kapp's paper; but although treating on the same subject, the two papers were widely different, that of the Drs. Hopkinson being of the highest interest to mathematicians, but too abstruse for the ordinary reader.

In a magnetised bar most of the lines leave at one end and enter at the other, forming closed curves in space. Some lines, however, always escape from the bar before arriving at the ends, making a shorter return than they would otherwise be able to do. "Polarity"—that is, the power of repelling one end or "pole" of an independent magnet—is evinced wherever a line of force issues from or enters into the iron. In practice, however, that part of the bar at which the ingress or egress of lines is densest is termed the pole.

All lines of force being closed curves it is evident that there must necessarily be two points in the bar which accord with the definition of a pole differing from each other in sign only.

By bending the magnet round, so as to bring the ends near together, we may reduce the length of the air gap by which the magnetic circuit is completed, and on causing the ends to touch each other all polarity disappears. The lines, however, still exist in greater numbers than before, on account of the superior conductivity of their circuit.

The following important facts relating to magnetism can now be summed:—

1. Practically speaking, iron is the only magnetic substance known.
2. The difference in the permeability of magnetic and non-magnetic substances is one of degree. Thus
3. Both magnetic and non-magnetic substances offer resistance to the passage of lines of force.
4. This resistance in non-magnetics is unaffected by saturation and varies as $\frac{\text{length}}{\text{cross section}}$.
5. The resistance of iron is not constant, but is affected by saturation.
6. That magnetic lines of force have not necessarily any connection with magnetic poles, but may exist in closed circuits without the existence of magnetic poles.

The connection between magnetism and electricity is not precisely understood; we can, however, follow to a logical conclusion certain results which are obtained by experiment, and form our ideas accordingly. We have experimental evidence for the fact that an electric current is always attended by a kind of magnetic sheath consisting of lines of force arranged in concentric circles around the axis of the electric conductor. The direction and comparative strength of these lines are rendered visible by threading a card upon the wire so as to form a plane at right angles to it, and dusting iron filings over the card. These will then be seen to arrange themselves in the path of the lines, which in non-magnetic media, as we have before stated, will be directly proportional to the current. (See Fig. 2.)

Fig. 2.

So far there has been no need for the conception of electrical resistance. It is evident, however, that in the case of a converse action to the one described, where by some means magnetic lines be employed to generate a current, the *resistance* of the conductor will play an important part in the final result.

If it were possible to obtain an electric circuit absolutely without resistance, we might logically expect that by merely placing a portion of the same in the midst of, and at right angles to, the lines of a magnetic field, a current, correspond-

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ing in strength to the number of lines passing tangentially across it, would immediately flow.*

The presence of resistance in the circuit, however, precludes the existence of such a state of things as this, and renders the expenditure of some energy necessary.

The operation by which energy is expended in this case consists in the movement of the lines in respect to the conductor, hence the scientific dictum that electrical resistance is a quantity in the nature of and expressible in terms of a velocity.

The *effort* to push a current through a resisting circuit is called electromotive force, and is, as we now see, proportional to the velocity with which a definite number of lines are carried across the conductor at right angles.

A quantitative statement of the above is generally made as follows:—The difference of potential created at the ends of a wire b centimetres long, when moved at a velocity of v centimetres per second across the lines of a uniform field of magnetic intensity M, so as to cut $M\,b\,v$ lines per second, is $Mbv\,10^{-8}$ volts, M being taken in absolute measure. When speaking of the electrical condition of two points in an electrostatic or electro-dynamic circuit we use the phrase "difference of potential," and we understand by that term a state in which energy would be expended between those two points upon effecting a suitable communication from the one to the other. This is the condition created at the ends of a wire when moving across the lines of a magnetic field.

The amount of energy which is expended upon joining two such points by a conductor is measured by the product of the difference of potential into the quantity of current which flows in consequence of such difference, just as the energy expended between two levels of water is the product of the difference of level into the volume of water permitted to fall from the one to the other.

The quantity of electricity passing between two points at any moment is measured by the quotient of the difference of potential at those points by the resistance of the conductor joining them. The factor of time is also used when the total amount of electricity is required for the estimation of materia electrolytic effects. From the above we see that the energy in any conductor may be written in either of the following ways:—

$$W = EC, \qquad W = C^2R, \qquad W = \frac{E^2}{R},$$

where E = the value for the difference of potential, R = the resistance of the conductor, and C = the current. When a difference of potential between two points in a closed circuit is continually maintained, a current flows from the point of high potential to the point of low potential in the inactive part or "external circuit," and from the point of low potential to that of high potential in the active part or internal circuit.

The energy required to force a current C against an opposing potential E is $EC + C^2 r$, r being the resistance of the conductor joining the points. The internal circuit may thus be regarded as a "feeder," taking in energy from some outside source, and pouring it into the external circuit.

To the difference of potential E at the ends of the active portion of a closed circuit there is thus always another quantity to be added in order to arrive at the total potential force or effort in the circuit, viz., that represented in the value Cr. The total value $E + Cr$ cannot be termed a difference of potential, as in that case the circuit would have to be supposed as divided at some point, which is not the fact; we have therefore to express the required conception by the words electromotive force, meaning, as before, the force which gives rise to difference of potential in the circuit.

The direction in which this E.M.F. acts in a closed circuit, or in which the potential is directed in an open wire, depends on the physical direction of the line cutting. From our knowledge of the principles of the conservation of energy we should at once say that the direction of the E.M.F. in a closed circuit must also be such as to offer opposition to the force which called it into existence, otherwise energy would be created. The above law, as applied to the direction of electrical currents, was first formulated by Lenz, and is very important.

(To be continued.)

* The argument in support of the above statement is as follows:—If we wish to produce a current, C, in a circuit of resistance R by moving a portion of the same across the lines of a magnetic field sufficiently removed from other parts of the circuit, we find that a certain velocity, V, has to be attained, and that V varies with R. Now, imagine V and R to diminish together, C remains constant, and, so long as V exists, will flow in a certain direction. If we now suppose V and R to vanish together, C will remain constant as before, and there being nothing to change its course, may be supposed to flow in the same direction as before.

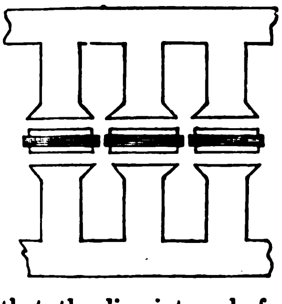
Of course *de novo* no direction could be properly assigned for the current, and the reasoning is just similar to that which would be employed to arrive at the conclusion that a projectile shot out into space would, at an infinite distance from all other matter, go on for ever *in the same direction.*

NOTE ON THE THEORY OF THE ALTERNATE CURRENT DYNAMO.*

BY JOHN HOPKINSON, M.A., D.SC., F.R.S.

According to the accepted theory of the alternate current dynamo, the equation of electric current in the armature is $\gamma y + R y =$ periodic function of t, where γ is a constant coefficient of self-induction. This equation is not strictly true, inasmuch as γ is not in general constant,† but it is a most useful approximation. My present purpose is to indicate how the values of γ and of the periodic function representing the electromotive force can be calculated in a machine of given configuration.

To fix ideas, we will suppose the machine considered to have its magnet cores arranged parallel to the axis of rotation, that the cores are of uniform section, also that the armature bobbins have iron cores, so that we regard all the lines of induction as passing either through an armature coil, or else between adjacent poles entirely outside the armature. The sketch shows a development of the machine considered. The iron is supposed to be so arranged that the currents induced therein may be neglected. We further suppose for simplicity that the line integral of magnetic force within the armature core may be neglected.



Let A_1 be the effective area of the space between the pole piece and armature core when the cores are in line; l_1 the distance from iron to iron.

Let A_2 be the section of magnet core, l_2 the effective length of a pair of magnet limbs, so that l_2 may be regarded as the length of the lines of force as measured from one pole face to the next.

Let m be the number of convolutions in a pair of magnet limbs, and

n the convolutions in one armature section.

T the periodic time.

The time is measured from an epoch when the armature coil we shall consider is in a symmetrical position in a field which we shall regard as positive.

x and y are the currents in the magnet and armature coils, the positive direction being that which produces the positive field at time zero.

At time t the armature coil considered has area A_1',

$$= b_0 + b_1 \cos(2\pi t/T) + b_2 \cos(4\pi t/T) + \&c.$$

in a positive field, and area A_1''

$$= b_0 - b_1 \cos(2\pi t/T) + b_2 \cos(4\pi t/T) - \&c.$$

in a negative field where

$$b_0 + b_1 + b_2 + \ldots = A_1,$$

and $$b_0 - b_1 + b_2 + \ldots = 0.$$

The coefficients b_0, b_1, &c., are deducible by Fourier's theorem from a drawing of the machine under consideration.

Let I be the total induction in the magnet core, and let at time t I be distributed into I′ through A_1', I″ through A_1'' and I‴ as a waste field to the neighbouring poles.

* Paper read before the Royal Society.

† "On the Theory of Alternating Currents," Telegr. Engin. Journ. Vol. 13, 1884, p. 496.

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The line integral of magnetic force from the pole to either adjacent pole is I'''/k where k is a constant.

We have first to determine I', I'', I''', in terms of x and y.

Take the line integral of magnetic force in three ways through the magnets, and respectively through area A_1', through area A_1'', and across between the adjacent poles—

$$l_2 f\left(\frac{I}{A_2}\right) + 2l_1\frac{I'}{A_1'} = 4\pi m x + 4\pi n y,$$

$$l_2 f\left(\frac{I}{A_2}\right) + 2l_1\frac{I''}{A_1''} = 4\pi m x - 4\pi n y,$$

$$l_2 f\left(\frac{I}{A_2}\right) + \frac{I'''}{k} = 4\pi m x,$$

whence $\qquad I' + I'' + I''' = I$

$$= \left(\frac{A_1' + A_1''}{2 l_1} + k\right)\left(4\pi m x - l_2 f\left(\frac{I}{A_2}\right)\right) + \frac{A_1' - A''}{2 l_1} 4\pi n y,$$

when t, x, and y are given, this would suffice to determine I by means of the known properties of the material of the magnets as represented by the function f. We will, however, consider two extreme cases between which other cases will lie.

First.—Suppose that the intensity of induction in the magnet cores is small, so that $l_2 f(1/A_2)$ may be neglected, the iron being very far from saturation. We have—

$$I' - I'' = \frac{4\pi}{2 l_1}\left\{ m(A_1' - A_1'')x + n(A_1' + A_1'')y \right\}$$

$$= \frac{4\pi}{l_1}\left\{ m\left(b_1 \cos\frac{2\pi t}{T} + b_3 \cos\frac{6\pi t}{T} + \ldots\right)x + n\left(b_0 + b_2 \cos\frac{4\pi t}{T} + \ldots\right)y \right\}.$$

We see that the coefficient of self-induction γ in general contains terms in $\cos 4\pi t/T$.

Second.—In actual work it would be nearer the truth to suppose that the magnetising current x is so great that the induction I may be regarded as constant, and the quantity $l_2 f(I/A_2)$ as considerable. But as small changes in I imply very great changes in $l_2 f(I/A_2)$, its value cannot be regarded as known; we have then—

$$2l_1\frac{I'}{A_1'} = \frac{2 l_1}{A_1' + A_1'' + 2 k l_1}\left(I - \frac{A_1' - A_1''}{2 l_1} 4\pi m y\right) + 4\pi m y.$$

$$2l_1\frac{I''}{A_1''} = \frac{2 l_1}{A_1' + A_1'' + 2 k l_1}\left(I - \frac{A_1' - A_1''}{2 l_1} . 4\pi m y\right) - 4\pi n y,$$

whence

$$I' - I'' = \frac{(A_1' - A_1'')I}{A_1' + A_1'' + 2kl_1} - \left\{\frac{(A_1' - A_1'')2}{A_1' + A_1'' + 2kl_1} - (A_1' + A_1'')\right\}\frac{4\pi n y}{2 l_1}$$

$$= \frac{(A_1' - A_1'')I}{A_1' + A_1'' + 2kl_1} + \frac{4A_1'A_1'' + 2kl_1(A_1' + A_1'')}{A_1' + A_1'' + 2kl_1} . \frac{4\pi n y}{2 l_1}.$$

For illustration, consider the simplest possible case: let $b_0 = b_1 = \frac{1}{2}A_1$, and $b_2 = b_3 = \ldots = 0$, and let $2kl_1$ be negligible; we have—

$$I' - I'' = I\cos\frac{2\pi t}{T} + A_1 \sin^2\frac{2\pi t}{T} . \frac{4\pi n y}{2 l_1},$$

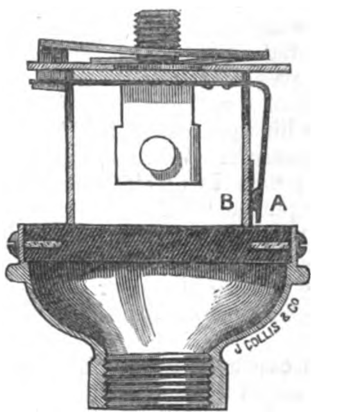
and the equation of current will be—

$$R y = n\left\{\frac{2\pi}{T} I \sin\frac{2\pi t}{T} - \frac{2\pi n A_1}{l_1}\frac{d}{dt}\left(\sin^2\frac{2\pi t}{T} . y\right)\right\},$$

instead of the simple and familiar linear equation.

INCANDESCENT LAMPS FOR SERIES CIRCUITS.

The question of working incandescent lamps upon arc-lighting circuits has of late received a great deal of attention in the United States. In this country it is well known that Mr. Alexander Bernstein has done excellent work in that direction, and in our issue of January 7th of the present year we gave a detailed description of the marked improvements which he has recently introduced into his system. Until recently the attention of the American electricians has been directed chiefly to the "multiple series" system, in which any number of arc lamps can be displaced by an equivalent number of incandescents of any required voltage connected in multiple series. The disadvantage of this plan is that it entails the expense of an automatic switch for the protection of each parallel, in order that when one lamp breaks another may be switched into the circuit. The Thomson-Houston Company have, however, recently turned their attention to the production of low-resistance lamps, to work with the same current as their arc lamps, and which can, therefore, be placed in simple series with them or with one another, just as in the Bernstein system. It is thus only necessary to provide for short-circuiting the lamp in case the filament gives way. This is done in the extremely simple manner shown in the annexed illustration, which represents a holder for the Thomson-Houston incandescent lamp, with the external cover removed. In the figure A is a stiff, brass spring, which is in connection with one of the lamp terminals. The side B of the holder against which this spring presses is connected with the other terminal, but the spring A is insulated from B by a piece of paraffined paper, which is shown in section by a dark line in the figure. Now, when the filament gives way, owing to the self-induction of the armature of the machine, and of all the series coils of the arc lamps (if any) in circuit, an immensely high difference of potential is brought to bear at the moment between A and B, with the consequence that the paraffined paper is perforated, and the circuit is again completed through A and B. The only weak point which we find in this arrangement is that it does not seem to admit of any very easy replacement of the lamp while the circuit is in operation. A new lamp could of course be put into place, but we imagine that it would be hazardous to meddle with the spring A—the new lamp might or might not be making good contact. We are indebted to Messrs. Laing, Wharton, and Down for a specimen of this holder, from which our illustration was engraved. Further particulars as to the Thomson-Houston incandescent lamps will be found on page 297 of the present volume.



Another method of effecting the same purpose has recently been brought out by the Schuyler Electric Light Company, who make a 65 candle-power incandescent lamp to run in series with 10-ampere Brush arc lamps. In this case the cut-out is placed within the glass globe, and consists of two strips of copper attached to the terminals of the filament, and separated only by a thin sheet of mica. The loop is of a long and narrow shape, and when the filament gives way an arc is supposed to form and to travel downwards until it reaches the copper strips, which are then fused together by the intense heat, and so close the circuit. The company are exhibiting the experiment of breaking the globe of a lamp while running, with results as described. We feel, however, a little doubtful about this action taking place in a *good* lamp, when the filament gives way within the globe. Would not the formation of an arc denote a not very perfect vacuum?

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

Discussion on Mr. Desmond G. FitzGerald's Paper, "On Reversible Lead Batteries and their Use for Electric Lighting."

As stated in our last issue, the discussion on this paper was commenced by Dr. J. H. Gladstone, F.R.S., who was followed by Mr. W. H. Preece, F.R.S. The remarks of these gentlemen are given below:—

Dr. J. H. Gladstone, in opening the discussion, at the request of the President, said he had listened with very great attention and interest, as they might all imagine, to the able and valuable paper which had just been read to them. Having regard to the difficult and complex nature of

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the subject of reversible lead batteries, he thought he would consult their feelings and his own in not entering much into the general questions contained in the paper, but rather in speaking upon those points as to which the opinions of the writer of the paper either agreed or disagreed with his own. But, first of all, he would like to thank Mr. FitzGerald, and thank him most heartily, for the kind way in which he had referred to the work of Mr. Tribe and himself, and the way in which he had, to a certain extent, adopted some of their conclusions, at the same time criticising others. First of all, he would go to the criticisms of Mr. FitzGerald, and take them in order; and, dealing with the subject of local action—a matter of great interest, as the object of the lithanode battery was to get rid of that as far as possible—Mr. FitzGerald thought that they had made a lapsus, and he had been led to do so from his detestation of anything in the form of "white sulphate." Of course one could to a certain extent sympathise with an electrician in that feeling; but at the same time he must assure Mr. FitzGerald that, had it not been for the formation of the white sulphate, a Planté or a Faure battery would never have been seen at work. He therefore thought, while Mr. FitzGerald regarded that as an enemy in their batteries, it was one which was absolutely necessary, and which they must welcome there as a friend. Mr. FitzGerald had quoted from an inquiry which Mr. Tribe and himself had made in regard to local action, and although he (the speaker) had, through the kindness of the secretary, received Mr. FitzGerald's paper the previous night, he did not happen to look at it until late the next morning, but his memory was sufficiently fresh, though the book had been published four years ago, to speak on the matter with tolerable accuracy. What appeared to him as being somewhat singular was that the author of the paper should not exactly appreciate the arguments therein used in regard to local action, but when Mr. FitzGerald transferred the image in his mind to an image on the blackboard, he (Dr. Gladstone) at once saw the way in which Mr. FitzGerald had been led to understand them. Having drawn the figure of a cell showing two plates, one of peroxide and another of lead, with a certain space intervening between them, he said they had inquired why it came to pass that there was not a vigorous action between the two plates, as to which various conclusions had been drawn. When examined through a microscope, they found the effect very different from the image drawn on the board. Supposing they took a zinc plate with copper upon it, in a manner which he proceeded to show, and placed that in dilute sulphuric acid, they would have such an action that it would be like an explosion, and it would be all over in a few seconds. How was it that that did not take place when they took a plate of lead with peroxide upon it and allowed it to be interpenetrated with this dilute sulphuric acid? They attributed that to the formation at once of a thin film of sulphate of lead upon the metallic plate, which did not stop but impeded the action. This badly conducting sulphate of lead was sufficient to account for it. Mr. FitzGerald had said:—"In my view, the electrolytic resistance in the local circuit would be diminished instead of augmented by interposing even an almost impermeable (but more or less moist) coating of sulphate of lead between the peroxide and its support, excepting at one or more points where the peroxide and the lead would be in perfect contact." Here I cannot follow Mr. FitzGerald. There would be no local action whatsoever if this peroxide covered the lead plate, so that the sulphuric acid could not get at it. But let them bear in mind that he and Mr. Tribe did not suggest this as the sole explanation of the phenomenon, but he thought it explained that sulphate of lead was essential to the reduction of local action. It had been stated that a table was given in their book at page 6 which appeared to disprove the theory they set up; but on looking at that page he found that the experiment itself was a little misunderstood by the author of the paper. Having stated the discrepancy between Mr. FitzGerald's conclusion and his own, Dr. Gladstone said he could add that the table, rightly understood—although it diminished the arguments of Mr. FitzGerald very much indeed—still lent a little weight to that gentleman's objection. This, however, might be answered by saying that such experiments were very difficult to perform, and that no two preparations put side by side with any amount of care would be exactly alike, and he thought there was something more than that, because he had frequently observed in this kind of reactions there seemed to be a little time required in order to get the full swing of the chemical work. As to the formula which had been given in the paper to which they had listened—a formula representing his own and Mr. Tribe's views—he wished to point out that it had been given not in the form in which they had given it. In the present case it was given in a chemical form. In their book they gave it as an electrolytic formula rather than a chemical, expressing not merely the results of the reaction (which the chemical formula did), but representing the course of the reaction too. He had no fault to find with that, because it expressed their views, though in a somewhat different form from that which they adopted. What he objected to was the way in which Mr. Swinburne had referred to it, and the strictures that gentleman had passed upon the work. He had read the printed remarks where Mr. Swinburne said he wondered why, when they came to examine this question, chemists seemed to lose their chemical knowledge, and spoke as though they viewed sulphate of lead as containing the oxide. The error was certainly not theirs. If they had been mere chemists, he did not think they would have fallen into that error, because it was antiquated chemistry. There were to be found in the paper many remarks—strictures of great value—on the work connected with the incomplete reaction that took place in the Faure and Planté cell, as well as in regard to the fact that they never got the full amount of sulphate of lead. There was no doubt whatever that they did not get the complete reaction. In regard to the later formula, containing sesquioxide of lead, it was quite possible that there might be some compound of that kind formed; but, if he was not mistaken, Mr. Tribe looked into everything of that kind, and was unable to find any indications of their existence. It was, of course, a theory which might be held, but on the existence of this oxide, on fuller research, perhaps even Mr. FitzGerald would scarcely believe. He feared that his remarks had been rather lengthy; but he had touched only upon those as to which there was any divergence of opinion between the lecturer and themselves. He could only add, in conclusion, that he was very much obliged to Mr. FitzGerald for the way in which he had gone into this matter and considered it. They must not, however, suppose that any of their work in regard to it was final. If they arrived at any chemical formula of the reaction they knew that there were other things which would have to be taken into account, and that they ought to know the whole matter, and not the mere changes that took place. There were great difficulties which were not yet solved—difficulties connected with the conducting power of the mixtures and various other things which were most important when one came to prepare these batteries for actual use. It was to the labours of such men as Mr. FitzGerald, who possessed a practical knowledge of the subject, that they must look for the investigations of these points.

Mr. W. H. Preece said it was quite evident that Mr. FitzGerald in his paper had raised a question that would be discussed probably more from its chemical than from its electrical, or practical side. But it was because there was also a physical side to it that deserved a little consideration that the speaker was tempted to occupy a few minutes in mentioning some of the results of his own experience. He was a little surprised to find not only that Mr. FitzGerald but nearly every one who used secondary cells neglected to avail themselves of that most useful apparatus, the hydrometer. He had been using secondary cells practically for the past three years, and he had watched with the very greatest care, by means of hydrometers, the performance of those cells. The variations in the density of the solution of a cell were indicative of the chemical actions that went on there, and those who were interested in the question, and who were competent to make the calculations, could be supplied if they liked with the records that he had kept with a great deal of care for the past three years. His practice was this. In every cell there was a carefully adjusted hydrometer, and readings of those hydrometers were taken every hour while the cell was being charged, and they were taken every morning after the cells had been discharged. Now, they would see that in the formula that Mr. FitzGerald had put before them the cell is assumed to be charged, and when a cell is charged it is at its highest density, and it has dissolved into the greatest quantity of sulphuric acid. When a cell is discharged it passed through a process by which this sulphuric acid, that gave it density, was transferred into sulphate of lead. It was abstracted from the solution to which it gave weight. Now, the practice was to charge cells with a solution which had a density of about 1150, and after a little time those cells acquired a density when charged which would continue to be 1210. Supposing the cells when charged had a density of 1210, then in his cells, which were the 15 L. G. P. S. cells, there was a steady fall of one degree for every 9 ampere-hours taken out, and it was possible and easy to indicate with absolute accuracy to one ampere-hour the quantity of charge that had been taken out of the cell, and the quantity of charge that remained in. Usually the cells charged at 1210 ran down to about 1190 before they were recharged, and in charging it was found that for every 12 ampere-hours put in one degree of density of increase was observed. The result was that this careful observation of density showed exactly what had been going on, and it showed unmistakably that the chemical formula which had been given by Mr. FitzGerald was a true and accurate record of what took place. He wanted to point out that it was perfectly possible, by carefully calculating the variations of density and comparing them with the amount of sulphate that ought to be formed, for a test or check to be made on the accuracy of chemical formulæ. Mr. FitzGerald had an abhorrence of white sulphate. He (the speaker) thought that if that gentleman had had as much experience as he had had of various kinds of storage cells he would have found that this white sulphate was a necessity, and it was absolutely quite impossible to find cells without some indication of the presence of this sulphate. Sometimes, of course, it was in excess. They had an operation going on called sulphating, and on that point he would like to mention that the plan of using carbonate of soda had been tried by him with very great success. He went down to Mr. Barber-Starkie's place near Bridgnorth to see what could be done, and he found there that the set of cells that that gentleman had used had been apparently very seriously affected, but by shoving in a quantity of carbonate of soda he had succeeded in filling the cell with a solution of sulphate of soda, and by that means dissolving the abominable white sulphate. The speaker had repeated the experiments. He had several cells charged with various proportions of carbonate of soda and sulphuric acid, and he found there really was a certain proportion of soda which, properly applied to a cell, would entirely remove all the outward and visible appearance of the sulphate, but they could not remove it entirely. It was essential to the action, and its presence was indicated, as he had said, by the measurements of the density of the cell.

The discussion was then adjourned till yesterday (Thursday) evening, when it was resumed by Prof. Forbes, Prof. Silvanus Thompson, Mr. Sellon, Mr. B. Drake, Mr. F. V. Andersen, Mr. W. H. Tasker, and Prof. Ayrton. A full report will appear in our next issue.

The National Telephone Company.—The National Telephone Company send us a copy of their list of subscribers for the "Scottish North Central District," which includes the counties of Forfar, Perth, and part of Fife. We note that Dundee is now in telephonic communication with the towns of Perth, Forfar, Arbroath, Morpeth, and Newport. The last-named town is situated on the south side of the estuary of the Tay, and is connected with Dundee through a submarine cable. A number of new lines are in contemplation.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 407
The Practice of Dynamo Design. By Guy C. Fricker. Illustrated ... 412
Note on the Theory of the Alternate Current Dynamo. By J. Hopkinson. Illus ... 413
Incandescent Lamps for Series Circuits. Illustrated ... 414
Society of Telegraph-Engineers and Electricians ... 414
ELECTRIC LIGHTING BUSINESS IN AMERICA ... 416
Obituary ... 417
Correspondence ... 417
Incandescent Lamp Manufacture.—XI. By J. Swinburne. Illustrated ... 418
The Field Electric Tramway. Illustrated ... 419
Note on Induction Coils or "Transformers." By J. Hopkinson. Illustrated ... 420
Applications of Electricity to Mining Operations. By F. J. Rowan, C.E. (Continued.) 421
A Short Sketch of the Progress of Electrical Engineering in Japan. By I. Fujioka, M.E. 424
On Frölich's Theory of Compound Dynamos. By Karl Zickler. (Concluded.) Illustrated ... 424
Battery Resistance. Illustrated 426
Plans for Installing. By A. F. Upton ... 427
German Union Telegraph and Trust Company ... 428
City Notes, &c. ... 428
Companies' Share List ... 42C

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ARC LAMP.—*30 quart-size Groves will give you an arc of about 400 candle-power for at least a couple of hours; but for the purpose you name the lime light will be found far cheaper and less troublesome. If, however, you prefer the electric light, there are several batteries which are more useful than the Grove. Particulars of some of these are from time to time to be found in our advertisement columns.*

ELECTRIC LIGHTING BUSINESS IN AMERICA.

The meeting of the National Electric Light Association at Philadelphia, a brief mention of which occurred in our last week's issue, brings out into rather startling contrast the business aspects of Electric Lighting in the United States and in the United Kingdom. For many obvious reasons, one of which is purely local and geographical, electric lighting has made far greater strides in America than in the mother country; but it is plain to be seen, from the principal subjects which occupied the attention of the Philadelphia Convention, that freedom from legislative restrictions must be counted as among the foremost practical explanations of America's pre-eminence in this field of industry. We cannot attribute it to superior technical knowledge; certainly not to scientific advantages—though we should be ready to acknowledge our inferiority in either of these respects did the proceedings of the meeting in question afford us any ground for doing so. But the very reverse of this is actually the case, and probably the best informed of our American contemporaries would endorse our judgment on these points. What they lack, however, in exact scientific and technical attainments our American fellow workers make up for in enterprise, and a sturdy indifference to consequences which is pretty generally associated with what is called "go." Add to this the fact that there are no legal obstacles worth mentioning to hinder their going as fast as they please, and we have a tolerably sufficient explanation of the existence of such an assembly as the National Electric Light Association in the States, whilst we can match it with nothing of the kind here.

Had such a meeting as that to which we are referring been possible in London, its proceedings would have been overshadowed, not by the competitive jealousies which troubled the otherwise calm atmosphere at Philadelphia, but by the consciousness that no amount of talk—not even to the extent of "60,000 or 70,000 words" reported with pride by our New York contemporary, *The Electrical World*—would avail to make electric light business in this country a *national* business, so long as the nation, through its representatives in Parliament, is unable to undo the manacles which were put upon that business by the Act of 1882. All that our friends on the other side of the water have to complain of in the nature of restriction, so far as we can make out, is that municipal bodies are averse to overhead electric light wires, and are backward in constructing subways to shelter them underground. As to the former we rather commend the municipalities for their good sense; and as regards the latter, we suppose it is with them a pure matter of business; and as soon as it can be proved that the work would pay for itself by the rental of wires no doubt it will be done. The united action indicated by the existence of this association promises well for the success of such a project.

One other grievance American electricians have, or seem to think they have, in common with ourselves, though we should hardly have believed it. Their patent laws are somehow not to their liking. Patent commissioners have made certain recommendations for the amendation of these laws, but Congress has taken no notice. A hope is expressed that when Congress meets again, "with the aid of new Congressmen, something of value to inventors may be accomplished." We have heard language like this often before nearer home, and our experience goes to show that tampering with patent laws seldom satisfies anybody. Inventors are an ingenious race, but they have never yet invented a patent law that pleased them all round. American legislation relating to patents has been always held up to us as a model of liberality and enlightenment. Apparently we have copied some of its provisions which people on the spot consider its worst features. It is, perhaps, unnecessary to deprecate their paying us a similar compliment by copying Mr. Chamberlain's famous Bill for regulating electric lighting business in this country.

In one particular, however, we gather that our example is being followed—namely, in the amount of attention bestowed at this meeting on the discussion of incandescent lighting. Gradually the Americans are coming to the conclusion we arrived at long ago, that for general lighting purposes incandescent lamps and not arc lamps are the ones to be studied. To use the language of our contemporary before mentioned, "in an arc light meeting, practically nothing was mooted in regard to the arc light itself." We do not precisely understand what an arc light meeting is, nor what mooting in regard to the arc light may mean; but we gather that this form of light was not in favour, whilst "as regards the incandescent light," to quote again, "the greatest interest was felt in that department." This is as it should be, though the description is not. Much disappointment is

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expressed that nothing was said about the lighting of railway trains by electricity. "At a time when the public mind everywhere is agitated on this subject, and when electricity has proved its ability in this line, the omission was remarkable." We should think so, indeed. How glad would our own electricians be if the public mind were equally agitated on this subject here! But perhaps the railway companies, who have to be consulted in this matter, are not possessed of minds, and are "everywhere" alike, in America as well as in England, proof against "agitation."

On one other and still more important point we have to congratulate our American brethren. They are at length expressing themselves emphatically in favour of good workmanship. One or two of the best papers read before the Association were devoted to this aspect of electric lighting business. In the words of our New York contemporary—we quote them because no language of our own would put the case so tenderly—"it is plain that electric light men are aware that their prosperity, and, indeed, their very existence, depends upon the proper maintenance of their electric lines." From the context it is even plainer that what is meant by maintenance is in reality the original installation. Reference is made to the pecuniary losses from bad insulation; and to this is added "the danger to life and property" arising out of "errors of the past," which ought to be corrected or avoided in future. President MORRISON pointed out that much of the "existing evil" is due to "ruthless and shameless competition," which we take to mean reckless and disgraceful workmanship. We have sharpened our pen on many occasions in dealing with this part of electric lighting business at home, and we are glad to be seconded by competent authorities abroad. By all accounts there is rather more need for plain-speaking in that quarter even than with us. But be that as it may, the warning will be salutary, and the prospects of electric lighting are brightened everywhere by associated gatherings such as that we have been commenting upon, discussing their affairs with a single eye to business. It cannot be too often repeated that the one indispensable condition to success is public confidence; without that, even if every embarrassing legal obstacle were removed, no permanent or lucrative business will be possible. We need hardly add that competent workers and conscientious work are the best guarantees for this confidence; and we regret to notice that a paper offered to the Association on the subject of educating and training electric workmen was dropped out of its programme.

OBITUARY.

It is with unqualified regret that we have this week to record the death, after a lingering and painful illness, of Mr. ALFRED J. FROST, who held the office of librarian to the Society of Telegraph-Engineers and Electricians.

From the very inception of the society Mr. Frost took an active interest in everything that could tend to promote its objects, although it was not until the 1st of June, 1880, that he held any official post in connection with it. Up to that time, however, he had evinced such painstaking care in every task he assigned himself, that he was then appointed librarian to the society, an office which he filled with singular diligence and ability. Amongst his first duties in that capacity was to prepare for the press a catalogue of the materials which had been collected and bequeathed to the society by Sir Francis Ronalds. Of the manner in which Mr. Frost acquitted himself of this onerous and responsible work we prefer to let the annual report of the council for 1880 speak: "The completion and publication of the Ronalds catalogue is a fit subject of congratulation. It has been a work of much labour and considerable expense, but has resulted in the production of a volume of immense value to every student of electricity, and the praises so abundantly bestowed upon it by the English and the foreign press are a sufficient proof that the materials collected at the cost of so much time and money by the compiler, the late Sir Francis Ronalds, have been worthily dealt with by the editor, Mr. A. J. Frost, the society's librarian." The report further states: "A still greater subject for congratulation is afforded by the completion of the binding of the books and pamphlets comprising the library. This work, including the classification and formation into volumes of an immense number of pamphlets, has been carried out under the superintendence of the society's librarian." It was only last summer that Sir Francis Bolton, perceiving that Mr. Frost's health was rapidly giving way, with characteristic kindness invited him to spend a few weeks in the Wellenthal valley of the Hartz mountains, in Germany, where Sir Francis was then engaged in extensive mining operations. While there Mr. Frost's active mind could not rest, and he availed himself of his brief, and we are sorry to add, so far as his health was concerned, fruitless holiday, to assist Sir Francis in the collation of those facts which formed the subject of three articles, entitled "Historical Notes," on the electric light, subsequently contributed to the *Journal* of the society. For a period of about 15 or 16 years Mr. Frost acted as secretary to Mr. Latimer Clark, whose extensive library afforded him ample opportunity for indulging his taste for the classification of scientific publications and the preparation of lists, for which he seems to have had a natural aptitude. The results of many of his labours in this direction are well known to electricians through the society's *Journal*. As one of the rewards which he earned for his useful but all too brief connection with the society as librarian, it may be mentioned that he was elected a member of the council of the Library Association of the United Kingdom. For the last two years Mr. Frost was suffering from diabetes, and it was only too evident to all his friends that his days were numbered. He succumbed to the fatal malady on Tuesday last, and by his death it may be said without affectation that the Society of Telegraph-Engineers has lost a most able and painstaking servant, and all who enjoyed his personal acquaintance a genial and generous companion.

CORRESPONDENCE.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to the paper on "Secondary Batteries" contained in last week's issue, may I ask for the following information? In Table I. what does "per lb. of Pb" mean, lead oxide, plate, or what? The fragment of lithanode analysed is stated to have a capacity of 16 ampere-hours. Does this mean per lb. or per plate, and from what part of the plate was the fragment taken? Is there any evidence to show that the composition of the plate is uniform after discharge?

Mr. FitzGerald deplores not being able to get more than 16 ampere-hours useful capacity per lb. of active material. May I suggest to him that the reason of this is the bad conducting power of his plates, and that if the oxide were in more intimate contact with a good conductor it would be easy to obtain a useful capacity of 35—40, and in some cases 50 ampere-hours per lb. of active material, to say nothing of rendering the plate less brittle and possibly of increasing its life?

The "permanent" diminution of E.M.F. is, I believe, chiefly due to the exhaustion of the acid in contact with the active material, and as the acid recovers itself by diffusion so the E.M.F. picks up.

Mr. FitzGerald does not mention anything with regard to the life of his plates; it would doubtless be interesting to many of your readers if he could give us some information on this point, also if any of the Union cells can be obtained, and, if so, where.—Yours, &c., HERBERT W. BUTLER.

8, Wynne-road, Brixton, S.W.

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REESE LIBRARY OF THE UNIVERSITY CALIFORNIA

MAXWELL'S THEORY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having noticed the difficulty raised by a correspondent in your last issue on a point in the article on "Maxwell's Theory of Electricity," and having read the article, I venture to point out that the conception therein embodied of the interposing medium through which action at a distance is produced seems clearly put. For if we conceive in a given magnetic field that the surrounding medium is composed of spherical bodies rotating on the lines of force as axes whose velocity and equatorial expansion is in proportion to the strength of the field, and which thereby cause a tension of the medium in the direction of the lines of force, we have an explanation of the force experienced by a magnetised body placed in the field as being due to this tension, and its potential energy to the kinetic energy of the rotating cells

As regards the poles causing the field, these would have been surrounded by the medium of rotating cells at the time of their magnetisation, and therefore similarly we should say that the potential energy of the poles was due to the kinetic energy of the rotating cells in the medium.—Yours, &c,

March 15th. H. D. WILKINSON.

INCANDESCENT LAMP MANUFACTURE.—XI.

BY J. SWINBURNE.

Flashing. (Continued.)

There is another point to be considered. In a small factory it is very important not to keep a large stock of finished lamps, and it is also very important to keep everything going on regularly, and also to be able to supply large quantities of lamps of a given sort in a short time. Now, suppose the factory has a normal turn out of 200 a week, and orders come in irregularly; either a huge stock must be kept or demand for large numbers of lamps cannot be met, or orders can only be filled at the rate of 200 a week. The writer has devised the following arrangement to meet this difficulty:— Nearly all orders are for 20 candle-power and 16 candle-power lamps. These are chiefly ordered between 40 and 60 volts, and between 90 and 110 volts. There are four kinds of stock lamps made; that is to say, when no special order is in hand the whole factory is engaged on 110-volt and 60-volt lamps. These are made at the rate of, say, 200 a week; but the lamps are stopped immediately after sealing in—that is to say, they are not sent to the pump room. The result is an accumulating stock of unexhausted lamps. When an order comes in for, say, 50-volt lamps, enough 60-volt unexhausted lamps are taken, and these are reduced to 50 volts by flashing in the bulbs themselves. They are then exhausted and tested, so that the delivery can be begun almost at once. To meet large demands suddenly all that is necessary is to have a large pump room, and means of testing and flashing lamps rapidly. By such arrangements a small factory is enabled to fulfil large and sudden orders quickly.

For flashing in the bulb no special apparatus is necessary. The lamp itself is used instead of the flask, and the exhausting tube is pushed into a small hole in a rubber cork. A vacuum must be used in flashing in the bulb, as otherwise the glass of the lamp gets blackened. This process must always be carried on with great care, as the least deposit on the glass stops a great deal of the light. Lamps should not be flashed down very much this way. The resistance may be reduced 30 or 40 per cent., but not much more.

In a small factory, where a large stock of finished lamps is unadvisable or impossible, and where lamps do not come out quite right, the arrangement may be carried farther still. All lamps when first exhausted are sealed off the pumps with an inch or two of the tube left on. They are then tested and stocked, being labelled with their candle-power and volts and amperes. When an order for lamps of a given electromotive force comes in, those that suit from stock are first taken, and then enough of slightly higher volts are flashed down to the resistances necessary for their candle-powers. Thus, supposing the factory has been executing a large order for 55-volt lamps, and several have come out wrong, there will be 56, 57, and a few 58 and higher volt lamps over, and some 54, 53, and lower volt lamps. These will be wrong either in resistance or candle-power, or both; but the fault will generally be in the candle-power or surface of the lamp. If an order for 53-volt lamps comes in those already in stock have their tubes sealed off, and the 54, 56, and higher volt lamps are opened and flashed down. The table is referred to to find the resistance for each lamp, as in this process the flashing apparatus has often to be set for every two or three lamps. By this arrangement there are no wasters from inaccurate flashing or measurement, as the only result of a mistake is that the lamp has to be exhausted again, which is a small matter. This also saves waste from bad vacuums, as the lamp is merely exhausted again, whereas otherwise it is generally spoiled, as it is difficult to open a lamp and seal on a new exhaustion tube and seal off again without leaving an untidy pip.

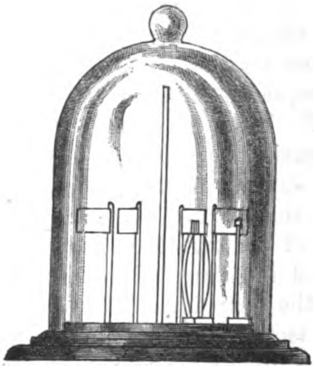

FIG. 5.

Flashing one carbon at a time is slow, as time has to be allowed to get a vacuum for each. Fig. 5 is the writer's arrangement for flashing six at once. An ordinary air pump plate and glass cover form the basis. On the top of the brass plate there is fastened a vulcanised fibre disc, with six pairs of mercury cups. The clips, instead of being fastened to a rubber cork, are fixed to a piece of hard insulating material, such as a domino, and project a little below, so as to dip into the mercury cups. There are two tubes, one for gas, and the long one for outlet, or vacuum. As there are six carbons, there are six leads and a return, making seven. The brass plate itself serves as one lead, and the pipes serve as two, so there are four insulated wires in addition. The pipes and the wires run through an air-tight rubber stopper. In the figure only two clips are shown in their places. The things like flags are pieces of mica on brass supports fixed to the vulcanised fibre. They are so placed that when a clip is in position the mica comes between the ends. This is necessary, because when a carbon breaks in a vacuum an arc is generally formed, which fuses the jaws of the clips. The mica prevents this. A six-way switch is used to connect up one carbon after the other. There are several sets of clips, so that while the jar is being exhausted the operator is mounting another set of carbons. By this method the process is carried on very rapidly. It often takes trouble to get the bell jar air tight, as bits of carbon and dust get on the ground plate. India rubber packing is generally needed. The jar is covered by a sheet tin guard in case of explosion; the safety vacuum gauge arrangement is also needed. Even then the average girl can blow it up somehow. These explosions are more troublesome when no vacuum is used. The gas supply should then be large, so that the dangerous time is short, and the operator should turn on the gas before beginning to arrange her next batch of carbons, and should not begin to flash till they are ready.

The electrical part of the flashing apparatus consists of an arrangement for automatically opening the circuit when the carbon has the desired resistance, or for showing the operator when the process has gone far enough. The current is generally supplied by a dynamo. The dynamo used should be either shunt or separately excited, and should be capable of

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giving 200 volts when fully excited. Some carbons need about 400 volts. The field circuit is led through an adjustable resistance in the flashing room, so that it can be regulated from there. A separately excited machine is best, because it can be varied through a greater range, as a shunt machine with a lot of resistance in its field circuit is unstable. Secondary batteries are infinitely preferable to work with, as they have no self-induction, and no resistances need be inserted. A pair of switches, with ten contacts in each, can then regulate the electromotive force from two to 200 volts by steps of two at a time. One switch is connected to 10 cells, and the other to 100 cells in the sets of 10. Small cells will do, as each operator uses only about three amperes for a little at a time. Secondary cells have also the advantage that each operator can get any electromotive force wanted without interfering with the others, while, with a dynamo, the electromotive force must be the highest wanted at the time, and must be brought down by resistance.

If the carbons have been carbonised at a low temperature it is necessary to use high electromotive force and resistance, as otherwise, when the carbon gets hot enough, it falls rapidly in resistance, and this increases the power spent, and breaks the carbon. Such carbons suddenly fall in resistance, and light up with a blaze. If the resistance in series is nearly as great as that of the carbon at first, this tendency is avoided, as the power increases slightly and then falls off again.

The resistance of the carbon might be measured by the current if the electromotive force were constant; but even with secondary cells accurate enough results could not be obtained in that way. It is therefore necessary to have a method that measures the resistance independently of the current and electromotive force. It is perhaps hardly necessary to say that it is of no use measuring the resistance of the carbons cold on an ordinary bridge, as carbon has a very much higher specific resistance when cold than when hot, and the ratio of these resistances has no known dependence on anything, and varies with different kinds of carbon.

The carbon may be arranged so as to be on one circuit through a differential galvanometer. Any form of differential galvanometer can be used whose needle can be easily seen. The galvanometer should not be wound with two wires the same size, but should have one wire large enough to take the current through the carbon, while the other should be small, with 10 or 100 times the turns. In this circuit a resistance-box is inserted with coils running up to 2,000 or 20,000 ohms. The plugs in the box are arranged to give 10 or 100 times the resistance wanted. An adjustable resistance is arranged in series with the whole, so that the temperature of the carbon can be easily controlled by the operator. Simple as this arrangement sounds, it has many drawbacks. Thus, the operator may not see the galvanometer move, as it does so suddenly without any previous warning. The galvanometer needle is constantly getting reversed, as a current is suddenly sent round the instrument before the needle has time to turn round. The movement of the needle may be made to work a relay contact, which automatically breaks the carbon circuit; but such contacts are a continual source of trouble. The resistance boxes are also very troublesome, as they have to be very well designed to avoid heating, and they are apt to leak under the high electromotive forces, so that the carbons are flashed too low and spoiled. When a carbon breaks, the full electromotive force of the machine comes on the resistance box. Iron resistances should never be used in connection with such apparatus, as the iron is circularly magnetised, and has enormous self-induction, which rapidly destroys switches and contacts. Lamps made by other makers are preferable as resistances, as they have no self-induction and get rid of a great deal of power in a small space. Lamps can never be used as measured resistances, as their resistance depends on their temperature. Flashing at the pressure of the air cannot be done with the differential galvanometer, because the carbon is only lit up for a second or so at a time, and as it is cold when the current first comes on, the needle of the galvanometer gets thrown strongly one way even when the resistance hot is right. Instead of a carefully made resistance box, an adjustable resistance consisting of helices of small wire that can be clipped at any point may be used. To set the flashing apparatus, a standard box is inserted where the carbon is flashed, so as to take its place, and the plugs being arranged, the clip is set so that the galvanometer comes to zero. All the various flashing apparatuses can then be set by one resistance box, which is less costly, as these boxes are very troublesome and tedious to make.

The differential galvanometer may consist of two coils mounted on a bar so as to slide, with the needle between them. The distances of the coils from the needle can then be varied. One coil carries the current through the carbon, and the other is wound with fine German silver wire, so as to balance the main coil when arranged in shunt to the carbon. The apparatus is set by temporary insertion of the standard resistance and by adjusting the distances of the coils till the needle comes to zero. This arrangement has the advantage that the operator can watch the fall of resistance as the carbon is flashed, but it is as difficult to make such an instrment sensitive enough, as the field resulting from two coils with the needle between them is bad, and even if the needle is quite short, it does not alter its position enough with a relatively large alteration of resistance. This instrument cannot be used to control an automatic cut out, as the needle has to be small, and is not strong enough to ensure a good contact.

The writer has tried a double wound electromagnet with a polarised core, as it seemed as if such an arrangement would ensure some pressure on the contacts. The contacts worked very satisfactorily, but the polarised core magnetised the electromagnet and stuck against the wrong side. Probably a powerful D'Arsonval galvanometer would be the best thing for automatic contacts.

THE FIELD ELECTRIC TRAMWAY.

Electric tram and railway systems continue to make their appearance in the United States with astonishing frequency and regularity; and, indeed, it seems probable that this process will continue for some time yet, for (in America) it is natural that every firm or company engaged in the manufacture of electro-motors should be anxious to possess in addition a special method of applying their apparatus to tram and railway lines. The various plans necessarily bear a strong family likeness, although the points of detail upon which they differ will probably be found to have greater influence upon the actual value of the system than at first sight appears.

The last thing out in tram lines is a system due to Mr. Stephen Field, a name well known in connection with electromotors, and who is also the author of an elaborate scheme for electric railway working, which, we believe, is shortly to receive a trial upon the New York elevated lines. This electric tramway belongs to the species of "conduit" lines of the type first introduced by Mr. Holroyd Smith, but the points of difference from the representative type are not unimportant. Instead of a single conduit, placed in the centre of the line, Mr. Field employs two separate conduits, one underneath each rail. He is thus enabled to do away with the "trailer," and to substitute a simple collecting brush attached to the framework of the car and following behind the wheels. And, again, by the use of two separate and distinct conduits it becomes possible to employ two independent circuits from either or both of which the motors may be driven. The system is then capable of yet further development. It is proposed to place a dynamo at each end of the line, and to connect the positive terminal of one machine with the copper conductor in one conduit and the negative terminal with the insulated iron rail, and to reverse these conditions with regard to the second dynamo and its connection with the remaining conduit. These arrangements will be understood on reference to Fig. 1. The machines are thus connected in series, and the circuit will be completed from the first dynamo through the copper conductor, the contact brush, and the motor, to the second brush, the conductor, and second dynamo (entering at the negative terminal) to earth, to which also the negative pole of the first dynamo is joined. Thus,

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under normal conditions, the actual difference of potential between the terminals of the motor is due to the sum of the differences of potential between either conductor and the earth; and, further, this difference of potential will be constant throughout the line, inasmuch as the motor approaches one dynamo as it recedes from the other. Again, by connecting either of the motor terminals to earth (or in practice to the frame of the car) instead of to the copper brush, the motor remains in circuit with a single dynamo, and thus half-speed is easily attained.

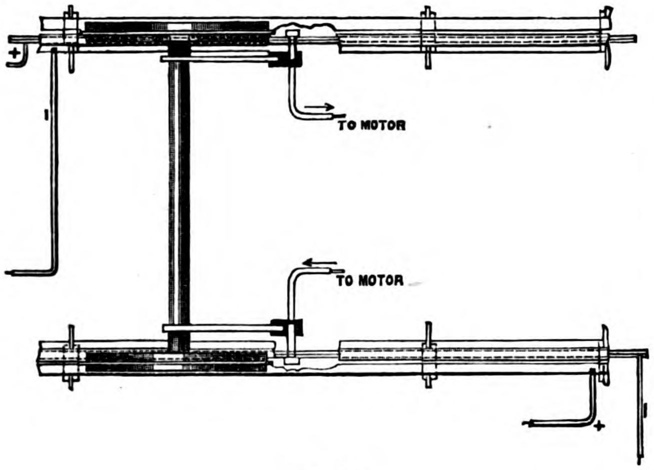

FIG. 1.

It also follows that the cars can still be run at half speed, even in the event of a breakdown at one of the generating stations. It must be admitted that these are important advantages, but it is also evident that extremely good arrangements are required for the insulation of the conductors from the iron rails beneath which they are placed.

The means by which Mr. Field proposes to effect the insulation and protection of the conductors are described as follows by the *Electrical World* of New York (we may add that the substance of the information given above has been obtained from the same journal):—

"The thorough insulation and stability of the conductors is provided for by the manner of their suspension and attachment. This is clearly shown in Fig. 2, which represent longitudinal and transverse sections and a plan respectively of the arrangement. The conductor is secured to a

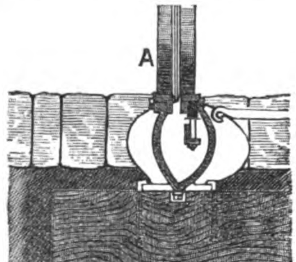

FIG. 2.

steel rod embedded in a composite conductor. The inner and outer shells of the insulator consist of hard rubber, and between them there is a layer of vulcanised elastic rubber. The whole is vulcanised together so as to form one piece. By the addition of the softer rubber the conductor is given a certain flexibility of motion, so that it can follow the pressure of the contact brush without undue strain on the insulator supports or pins. At the joints of the section of copper conductors a flexible bridge-joint is provided so as to allow for the expansion and contraction of the conductors.

"The details of the design of the conduits will be seen from Fig. 2, which is taken from the actual working drawings, calculated on the basis of a ten-mile road with 100 cars on each track; two slotted conduits are employed for each line of rails, the wheel flange running in the slot. (In the figure A is the wheel broken off at the top). The wheels are 30in. in diameter and the conduits themselves are only 8in. high. They are built up in lengths from two sections bolted together at the bottom, and let into the wooden cross ties. Heavy ribs are cast on the sides of the section, which are calculated to withstand a vertical pressure at any point of 16,000 pounds to the square inch. In addition, tie rods connecting the upper parts of the conduits lend additional stiffness to the structure and prevent any spreading or closing of the conduit slots.

"It will be noted that the wheels have different treads on each side of the flange, the inner being of smaller diameter than the outer tread. On a straight track the outer, larger tread of each wheel bears on the track. But when rounding curves, the wheel bears on the smaller tread on the inner rail, so that it has a slower motion than the outer wheel, and thus the friction usually encountered is avoided. The angle rails which are bolted to the tops of the conduits are raised only ½in. above the level of the pavement, and, being rounded, present no obstruction to ordinary traffic.

"These constitute the principal mechanical details of the road bed. Special provision has also been made for drainage of the conduits.

"Mr. Field intends also, in the line he proposes to equip, to lay pipes in the conduit through which hot brine will be circulated in winter so that all snow falling into the conduit will be melted. This device of course need only be put in operation during extremely cold weather. It will be noted that the conductors are placed at one side of the slot, so that any dirt or snow falling into the conduit passes clear of the former.

"No extra appliances for cleaning the conduit are deemed necessary, as, being only 8in. deep, it can be easily cleared of any refuse, with a shovel let into the slot, and by means of which the accumulation can be removed to the drains, which are provided at short intervals."

NOTE ON INDUCTION COILS OR "TRANSFORMERS."*

BY JOHN HOPKINSON, M.A., D.SC., F.R.S.

The transformers considered are those having a continuous iron magnetic circuit of uniform section.†

Let A be area of section of the core,
m and n the number of convolutions of the primary and secondary coils respectively,
R, r, and ρ their resistances, ρ being the resistance of the secondary external to the transformer.
x and y currents in the two coils,
a induction per square centimetre,
α the magnetic force,
l the length of the magnetic circuit,
$E = B \sin 2\pi(t/T)$, the difference of potentials between the extremities of the primary,
T being the periodic time.

We have

(1.) $4\pi(mx+ny)=l\alpha$;

(2.) $E=Rx-mA\dot{a}$;

(3.) $O=(r+\rho)y-nA\dot{a}$;

from (2) and (3),

(4.) $nE=nRx-m(r+\rho)y$

substituting from (1),

(5.) $x\{n^2R+m^2(r+\rho)\}=n^2E+(l\alpha/4\pi)m(r+\rho)$;

(6.) $y\{n^2R+m^2(r+\rho)\}=-nmE+(l\alpha/4\pi)nR$;

(7.) $$A\dot{a}=-\frac{(r+\rho)mE}{n^2R+m^2(r+\rho)}+\frac{l\alpha R(r+\rho)}{4\pi\{n^2R+m^2(r+\rho)\}}.$$

We may now advantageously make a first approximation, neglect $l\alpha$ in comparison with $4\pi mx$, that is, assume the permeability to be very large, we have

(8.) $$A\dot{a}=-\frac{(r+\rho)mB\sin(2\pi t/T)}{n^2R+m^2(r+\rho)};$$

* Paper read before the Royal Society.

† For a discussion of transformers in which there is a considerable gap in the magnetic circuit, *see* Ferraris, *Torino, Accad. Sci. Mem.*, Vol. 37, 1885, Hopkinson, "On the Theory of Alternate Currents," Telegr. Engin., *Journ.*, Vol. 13, 1884, p. 496.

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$$(9.)\ \mathrm{A}\,a = \frac{(r+\rho)\,m\,\mathrm{B}\cos(2\,\pi\,t/\mathrm{T})}{\{n^2\,\mathrm{R}+m^2\,(r+\rho)\}\,.\,2\,\pi/\mathrm{T}}.$$

For practical purposes these equations are really sufficient. We see, firstly, that the transformer transforms the potential in the ratio n/m, and adds to the external resistance of the secondary circuit ρ a resistance $(n^2\,\mathrm{R}/m^2)+r$. This at once gives us the variation of potential caused by varying the number of lamps used. The phase of the secondary current is exactly opposite to that of the primary.

In designing a transformer it is particularly necessary to take note of equation (9), for the assumption is that a is limited so that $l\alpha$ may be neglected. The greatest value of a is $\mathrm{B}/\{(2\,\pi/\mathrm{T})m\,\mathrm{A}\}$, and this must not exceed a chosen value. We observe that B varies as the number of reversals of the primary current per unit of time.

But this first approximation, though enough for practical work, gives no account of what happens when transformers are worked so that the iron is nearly saturated, or how energy is wasted in the iron core by the continual reversal of its magnetism. The amount of such waste is easily estimated from Ewing's results when the extreme value of a is known, but it is more instructive to proceed to a second approximation, and see how the magnetic properties of the iron affect the value and phase of x and y. We shall as a second approximation substitute in equations (5) (6) (7) values of α deduced from the value of a furnished by the first approimation in equation (9).

In the accompanying diagram (Fig. 1) Ox represents α, Oy represents a, and Oz the time t.

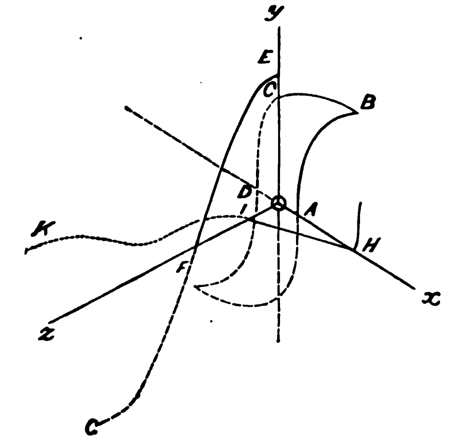

Fig. 1.

The curves A B C D represent the relations of a and α. E F G the induction a as a function of the time, and H I K the deduced relations between α and t. We may substitute the values of α obtained from this curve in equations (5) and (6), and so obtain the values of x and y to a higher degree of approximation. If the values of α were expressed by Fourier's

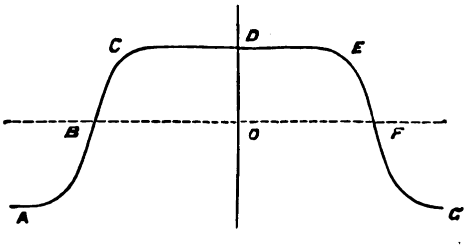

Fig. 2.

theorem in terms of the time, we should find that the action of the iron core introduced into the expression for x and y, in addition to a term in cos $(2\,\pi\,t/\mathrm{T})$ which would occur if a and α were proportional terms in sin $(2\,\pi\,t/\mathrm{T})$ and terms in sines and cosines of multiples of $2\,\pi\,t/\mathrm{T}$. It is through the term in sin $(2\,\pi\,t/\mathrm{T})$ that the loss of energy by hysteresis comes in.

A particular case in which to stay at a first approximation would be very misleading is worthy of note. Let an attempt be made to ascertain the highest possible values of a by using upon a transformer a very large primary current and measuring the consequent mean square of potential in the secondary circuit, by means of an electrometer, by heating of a conductor, or other such device. The value of a will be related to the time somewhat as indicated by A B C D E F G in Fig. 2; for simplicity assume it to be as in Fig. 3, the

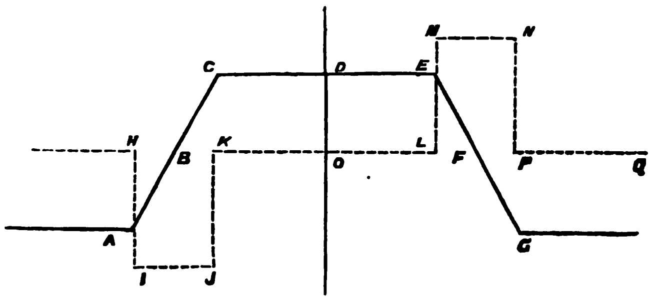

Fig. 3.

resulting relations of potential in the secondary and the time by the dotted line H I J K O L M N P Q. The mean square observed will be proportional to ML $\sqrt{}$LP, but ML $\sqrt{}$LP is proportional to EL, hence the potential observed will vary inversely as $\sqrt{}$LP, even though the maximum induction remain constant. If then the maximum induction be deduced on the assumption that the induction is a simple harmonic function of the time, results may readily be obtained vastly in excess of the truth.

APPLICATIONS OF ELECTRICITY TO MINING OPERATIONS.

BY F. J. ROWAN, C.E.

(Continued from page 378.)

II. Winding.

Early in 1881 Captain Brain made some interesting experiments in winding by an electro-motor, which may be quoted. He constructed "an incline plane of 1 in 6 with ordinary colliery rails, and of the same gauge as in the works, viz., 2ft. 7in. One of the colliery tubs was placed on this plane, the tare of which was 7cwt. 2qrs. 14lbs., having a load of castings 2,898lbs., making a gross weight of 3,752lbs., and constituting a working load equal to 1 ton 5cwt. of coal nett, this being above the maximum weight, and combining, as far as possible, the same conditions of friction and other elements per tub as were met with in his underground workings The winding apparatus at the top of the incline consisted of a drum 2ft. in diameter, with two sets of spur gearing at 3 to 1, making 9 to 1, with a pulley 4ft. diameter for a belt, the driving pulley of the electro-motor being 5in. diameter. A light wire rope was attached to the drum and to the tub." The winding apparatus and the spur gearing were much too heavy for the work, and added unnecessarily to the friction, but no allowance was made for this in the numerical results, the gross being taken 3,752lb. × 7 ÷ 33,000 = the horse-power for every 7ft. vertical in 1min. The number of seconds required to attain the 7ft. vertical rise was carefully noted by a stop watch, and after some weeks the electrical working was so controlled that the motor, which was the one afterwards applied to pumping, raised the load in 12 seconds, this being equal to 3·97 horse-power exerted, or nearly 2 horse-power for each 1 cwt. of weight of motor, or in other words equal to a colliery winding engine weighing only 66lb. for each horse-power it exerts. Since this result was obtained, in March, 1881, the efficiency of electro-motors has been considerably increased, so that better results can be obtained now.

A modern form of motor which has so far given remarkably good results is that of Mr. Moritz Immisch, who has kindly sent me some illustrations and notes about his motor. Mr. Immisch has departed from the ordinarily received ideas on the subject of motor construction. He does not admit that the best dynamo is necessarily the best motor; but while admitting fully the theory of reversibility, he says that an efficient dynamo must, from the nature of things, be an ineffi-

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cient motor. The dynamo in ideal has an enormously powerful field and a very weak armature, or in other words the magnetic moments of the field and armature are as widely different as possible. The principle is carried out fairly well by all the best dynamo makers. Mr. Immisch, however, believes that the motor should have an armature and field with relatively equal magnetic moments. This result can only be obtained by making the armature much larger in proportion to the total weight of the machine than is considered advisable in a dynamo. Strong evidence that this theory of motor construction is correct is derived from the high efficiency which the Immisch motor gives—an efficiency very nearly double that of motors made on the dynamo type. On a recent occasion an Immisch motor was tested against one of these others by a well-known maker, when it was found that for the same work the Immisch motor used exactly half the current at the same E.M.F., thus giving double the efficiency of the other, and causing the commercial cost of the power developed to be reduced by one-half.

Another point of great importance upon which Mr. Immisch lays considerable stress is that in his motors there is an absence of what is technically called "lead." From this it results that the motor may be run at any load within that for which it is designed without the brushes being adjusted and without sparking. The importance of this can readily be estimated for all cases in which the load varies rapidly.

This fixed position of the brushes is arrived at by a special method of winding the armature, which is applicable to either drum or cylinder armatures. The drum type is used for low tensions, and the cylinder for high tensions or extra low speed. The coils of the armature are so connected to a commutator of suitable construction that the coils lying along the diameter joining the brushes are cut out of circuit by being closed on themselves. The reason for this construction is that these coils, if active, would tend to induce poles in the armature at right angles to the axis of magnetism. This would weaken both the armature and the field, because in the motor the field and the armature tend to mutually strengthen each other. The chief advantage gained by this arrangement of coils is that the resultant axis of magnetism is formed beneath the short-circuited coils, and induced currents in these coils tend to keep it in a fixed position.

By following out these principles of design Mr. Immisch has succeeded in producing a motor, which, with reference to weight, power, efficiency, or durability, is most successful.

A machine weighing about 350lb. will give 8 brake horse-power, at a speed of 1,400 revolutions per minute. The efficiency, as tested by a Prony brake or dynamometer, averages 85 per cent. between 4 and 8 horse-power.

The efficiency of these machines ranges from 70 per cent. in a 1 horse-power motor to 90 per cent. in one of 20 horse-power. Measured by what is technically called "torque," which is the effort exerted to cause rotation, they show a very large amount of power in proportion to their weight. Mr. Immisch's electrician informs the writer that a machine of the same size will lift and maintain at its normal torque a weight of 14lb. at the end of a lever of 2ft. This is equivalent to a torque of 176ft. lb., and is equal to a pull of 112lb. on the periphery of a pulley of the same diameter as the armature, viz., 6in. At the same time the motor could momentarily exert a maximum torque of about five times that amount without damage.

At the *Thibaut shaft of the Société Anonyme de Saint Etienne* an electric winding engine was in 1883 at work, drawing from 20 to 28 tons in ten minutes up a 13 fathom shaft. A Gramme generator at the bank was driven with belt gearing of 20 to 1, by a small horizontal steam engine of 5 indicated horse-power. The motor, which was also a Gramme dynamo, was fixed at the bottom of the shaft, and geared to the winding drum at 250 to 1. Of the power indicated by the steam engine, 15 per cent. was absorbed by its own friction, and 50 per cent. was absorbed by the electric apparatus. The useful effect of the whole installation, which cost about £340, was 25 per cent.

In this case, neither the steam engine nor the electro motor seem to have been properly efficient specimens.

At the mines of *La Péronnière*, near Rive de Gier, *in the Loire Valley*, extensive trials of electricity were carried out. A steam engine of 32 horse-power was used to drive a pair of Gramme dynamos, each of 8 horse-power. The current was carried from them by cables of 16 No. 20 B.W.G. copper wires to a pair of similar machines placed in the workings and used as motors. The shaft is 437 yards deep, and the distance the current was carried was in one case 1,312 yards (1,200 metres) to a staple up which coal is drawn, and, in another case, 1,650 yards to a gin bank. The motor was in one case attached to a drum which stands at the head of an incline 120 yards (110 metres) long with a gradient of 14½in. per yard (4 centimetres per metre). The load raised was about 1,760lb. (800 kilograms), and the ascent was made regularly in 1½min. The work went on with great rapidity, starting and stopping being effected as gently as desired. It is stated that about 5·2 horse-power was used, and that the useful effect was 30 per cent. with 1,280 revolutions per minute of the generator, but higher with a greater number of revolutions. During the whole of November, 1881, when this apparatus was under test in regular working, not a shift was lost or a tub stopped.

The experiments made at these mines included distances up to 3,280 yards (3 kilometres), and proved that the useful effect obtained varied very little with the distance. Messrs. Charousset and Bague, who have published the results of the working of this plant, have based upon their experience with it the following estimate of the cost of electrical winding plant to lift 1½ ton of coal from a depth of 22 fathoms in 151 seconds (2 minutes, 31 seconds) :—

Steam engine, 20 horse-power	£258
Bedplate for engine, 4 Plummer blocks, 2 Plummer bottoms, 5 lubricators, shaft for friction pulleys, shaft to drive Gramme machine, 5 pulleys, driving belt, contact gear, pins, bolts, &c.	150
Gramme machine of 8 horsse-power (generator)	140
Electric and speed meters	13
Total at Bank	£561
Gin complete	312
Gramme machine (motor)	140
Total	£1,013

To this must be added the cost of cables at 11d. per yard in dry places, and 2s. 2·33d. per yard in wet places. Also the cost of erection both above and below ground.

At *Blanzy Mines* experiments have been made with an electric gin for drawing coal to a bank at St. Chamond Pit. The gin was set up under a set of shear legs carrying a pulley over which a chain was passed—one end being wound on the gin or drum, and the other end carrying weights. These weights were varied from 13 to 30 cwts, and these were drawn up to the gin. The useful effect was obtained by comparing the work in weight raised with the power transmitted to the generating machine—a Gramme dynamo. The loss, therefore, includes that due to the friction of the gearing, &c., of the gin, the friction of friction-cones connecting the Gramme motor with the gin, that of the pulley on the shear legs, and that of the chain on the pulley and drum. The useful work done varied from 0·73 to 4·30 horse-power.

The length of the conductors up to 700 yards, the extent of the trials, had no sensible effect on the useful work done.

The useful effect reached a maximum of 51½ per cent. when the Gramme machines were working to their full power.

III. Haulage.

At Zankerode Pit.—In the autumn of 1882 the system of haulage by means of an electric locomotive was established in the fifth main crosscut of the Oppel Shaft of the Royal Colliery at Zankerode, near Dresden, in Saxony. This has been alluded to by Mr. Arnold Lupton in the *Transactions* of the Midland Institute of Engineers, and more recently by Mr. R. T. Moore in Vol. VI. of our own *Transactions* (p. 165). Both of these communications are accompanied by sketches,

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No. of Observations.	No. of Waggons Drawn.	Tractive power of of engine. A including. B without. 15 Kg. for its down traction. A. Kg.	B. Kg.	Average speed per second. Met.	Work done by locomotive. Condition A. Kgm.	Condition A. H.P.	Condition B. Kgm.	Condition B. H.P.	Steam Engine. Total revolutions of steam engine during trip.	Revolutions per minute.	Indicated H.P.
1	10 full	95	80	2·34	222·3	2·97	187·2	2·50	885	200·4	7·8
2	15 full, partly badly greased	160	145	1·96	313 6	4·18	284·2	3·79	1,038	195·9	13·8
3	20 full, well greased	180	165	1·44	259 2	3·46	237·6	3·17	1,242	173·2	14·7
4	20 full, some badly greased..	230	215	0·78	179·4	2·40	167·7	2·24	?	?	?
5	10 empty.......................	50	35	2·76	138 0	1·84	96·6	1·29	798	217·8	4 9
6	15 empty.......................	60	45	2·66	159·6	2·13	119·7	1·59	830	212·8	6·0
7	20 empty.......................	75	60	2·34	175·5	2·34	140·4	1 87	833	189 0	8·6

and Mr. Moore gives, at Plate XII., of Vol. VI., an illustration of the locomotive, which has been lithographed from a photograph.

The level or road at Zankerode is about 240 yards (220 metres) below the surface, and is about 790 yards (720 metres) long. It runs in a south-westerly direction from the first bottom in a straight line to the seam of coal, and receives the full tubs from the different workings, partly from a self-acting incline, and partly from the fifth main level which is driven on the course of the seam. The length of line, clear of the sidings at each end for making up trains, is about 680 yards. In running, the South-Eastern line is used by full trains, and the North-Western one by empty ones, the switching always taking place to the right. As the locomotive is reversible, and has a seat with the controlling handles at each end, it does not require to be turned. The tubs are of about 15 cwts. gross weight, the load being in each 10 cwts. of coal. The total load of the trains is said by Mr. Lupton to have been, when he saw them running, 13½ tons, or 18 tubs each, weighing when empty 5 cwts., and holding 10 cwts. coal. Mr. R. T. Moore states the size of the race at 15 tubs and the total work at 25 runs, or 200 tons drawn per day. Mr. B. R Förster, however, states that in 1883 the total quantity drawn during the 16 working hours, between 4 a.m. and 8 p.m., was 600 tubs, or 300 tons, and that this can be increased to 800 tubs, or 400 tons when in full work.

The details of line and waggons are as follows :—Gauge of line, 22in.; steel rails, 2½in. high, 2in. broad at the base, fish jointed, and weighing 13·6lbs. per yard. Waggons, 5ft. long, 2ft. 1in. broad, 3ft. 3in. high. Capacity, 3½ cubic feet. Weight, empty 550lbs., filled 1,595lbs. The locomotive is 8ft. long, 2ft. 7in. broad, 5ft. high, and weighs 3,520lbs. The total length of 8ft. includes the space occupied by the driver's seat at each end, the body of the locomotive being 3ft. 2in. long.

On the surface is an inverted cylinder steam engine with 10in. diameter of cylinder and 8in. stroke. A belt from the fly-wheel drives the generating dynamo, the pulleys being about 3 to 1. The dynamo is a Siemens No. Do size, running at about 660 revolutions per minute, the speed of the engine being 200. The current is led and returned by two naked conductors of copper wire as far as the shaft, which is nearly sixty yards distant from the dynamo. In the shaft well insulated cables are used for both working and returning currents, the main conductor being also armoured, and in the level or road the conductors are ⊥ shaped bars. Fixed along the roof and gripping the edges of the lower flange are sliding contact pieces, which are pulled along by the locomotive, and have insulated wires led from them to the electrical switch of the motor.

A variable resistance, consisting of a box containing bars of carbon immersed in water, is carried on the roof of the locomotive and is used to prevent the over-heating the coils of dynamo and motor by sudden variations of current passed through them. The amount of resistance thrown into circuit is gradually increased before stopping the locomotive, so that the dynamo is protected against the work being thrown off suddenly. This, however, is more or less of a complication, and might be avoided by shunt winding the machines.

The useful tractive effect of the locomotive was determined by a Schäfer and Budenberg spring dynamometer, which was read at regular intervals during several trips, indicator diagrams being taken at the same time from the steam engine at the surface. The results have been given by Mr. B. R. Förster in the above table, with the remark that the figures in the last column are not very exact owing to the difficulty of getting good diagrams from high-speed engines. It is said that the practical results obtained show that trains of fifteen full or empty waggons can be drawn at speeds varying from 2·25 to 3 metres per second (= 5 to 7 miles per hour) the distance of 620 metres (about 680 yards) being traversed in 3½ to 4½ minutes, the steam engine making 225 to 250 revolutions per minute.

The highest duty recorded in these observations is that of No. 2, which is 4·18 horse-power, but frequently the train of 15 loaded tubs is run at 3 metres velocity (7 miles per hour, *i.e.*, the speed noted by Mr. Moore), and this duty then becomes 6·4 horse-power. In arriving at the useful effects from No. 2 observation, 2·6 horse-power are deducted for the friction of the generator, this having been ascertained by a break test of the engine. The amount of power consumed in friction of the spur gearing used in the locomotive between the motor and the wheels on the rails is taken at 25 per cent. of the work realised, and thus the effect realised by electric transmission is as 11·2 : 5·22 = 46·6 per cent.

The consumption of steam at 50lb. pressure per square inch was 8·101 cubic metres = 286 cubic feet for a loaded train,

and 4·200 „ = 148·3 „ „ „ light „
or 12·301 „ = 434·3 „ „ for the round trip.

In addition to this, there is a small loss of steam on account of the steam engine being kept running when the locomotive is standing, unless when the stoppage is of some duration. The maximum due to this loss is, however, taken at 5 per cent. of the above quantity, so that the total consumption of steam per trip will not exceed 12·9 cubic metres, or 455 57 cubic feet, which, at the cost for steam at Zankerode, amounts to little more than 6d.

At the establishment of this line, Messrs. Siemens and Halske contracted to supply the necessary plant for an electric railway guaranteed to draw a gross load of 10 tubs or 7½ tons at a speed of 2 metres per second. The contract was for £700, and included one electric locomotive capable of travelling in either direction; one dynamo machine with steam engine; 700 metres of main (double) conductor, with insulators; 260 metres of cable for carrying the current from the dynamo to the workings; and sundry accessory and duplicate

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apparatus. The total cost of establishing the system was as follows:—

Contract as above	£700 0 0
Freight to mine	13 15 0
Steam pipes, bells, &c.	15 15 0
Signalling arrangements	15 15 0
Extra conductors, &c.	18 13 0
Total cost of erection	48 0 0
	£811 18 0

The erection was completed in September, 1882, by the staff of the colliery, without any special skilled assistants, an experienced fitter having first been sent for a week to the makers' works in order to become thoroughly familiar with the construction and working of electric machines.

The working cost for 660 waggons drawn per day of 16 hours is as follows:—

Driver's wages	£0 5 3	
Steam	0 2 3	
Engine drivers at surface	0 3 1½	
Lubrication, cleaning, and lighting	0 1 1½	
		£0 11 9
Interest and depreciation at 15 per cent. per annum for 300 working days = per day		0 8 1½
		£0 19 10½

Or about ·77d. per ton.

With the full daily quantity of 800 waggons, it is estimated that this cost will be reduced about 10 per cent. As compared with horse or man traction, the proportional figures given are:—

	Electric.	Horse.	Man.
For 660 waggons daily	3·01	3·71	6·2
„ 800 „ „	2·70	3·70	6·2

In the levels of the *Paulus and Hohenzollern Colliery*, near *Beuthen*, in Upper Silesia, an electrical railway was introduced in 1884. It is said to be similar to the one at Zankerode, but with more powerful machines.

The steam engine has one cylinder 24¾in. dia. and 3ft. 8in. stroke, the dynamo being driven by a belt from the fly-wheel.

The distance from the dynamo to the working level is 250 yards, and the total length of the line is 820 yards. The conductors of the electricity are arranged as at Zankerode.

The locomotive weighs 2 tons 2cwt.; the empty tubs weigh about 8¾ cwt., and they carry 10 cwt. of coal.

It is said that the cost of carriage by this electrical system has been found to be 0·191 pfennig per centner, or about ½d. per ton, this being about one-half cheaper than horse transport.

(To be continued.)

A SHORT SKETCH OF THE PROGRESS OF ELECTRICAL ENGINEERING IN JAPAN.*

BY I. FUJIOKA, M.E.

My present visit to this country with Mr. Yashima, president of the Tokio Electric Light Company, Japan, is to investigate the different systems of electric lighting and electric transmission of power which are now in actual use here, so that we might introduce to our country the best and most reliable system, and not to make advertisement of our work, if any. I am not well prepared to give you a full and clear sketch of the progress of electrical engineering in our country, and I think this short paper which I have the honour to read now before such a remarkable body of electric men as the National Electric Light Association would be nothing but a curiosity to you.

To begin with the electric telegraph. The first line was put up in 1869, if I remember right, with Breguet's A B C instrument. Since then many improvements were, of course, introduced, and now nearly all the towns, small or large, are electrically connected so that we can telegraph from any part of our country to any part of this country or anywhere else; only it is rather expensive, *i.e.*, about $2.80 per word from Tokio to New York. The instruments we use at present are mostly Siemens' Morse ink writers, and the wires are all overhead except over some wide rivers and straits, where, of course, subterranean cables are used. The Japanese telegraphs are completely under Government control.

It was in 1872 that the imperial engineering college was instituted in Tokio, and Prof. W. E. Ayrton, the well-known electrician, now in London, occupied the chair of the professor of telegraph engineering and natural philosophy, and stayed there for six years working in the line of electrical researches with Prof. John Perry, then professor of mechanical engineering in the same college. These two gentlemen's names are pretty familiar to you, I imagine, from their valuable labours in relation to electrical engineering and the ammeters and voltmeters of their invention. Mr. Thomas Gray, assistant to Sir W. Thomson, then stayed with us in the college for about three years, and I have been connected with the college for a number of years, attempting to keep up with the progress of electrical applications abroad. I was here in 1884 when the International Electrical Exhibition was held in this city.

The telephone business is yet quite poor in our country; only the Government offices and residences of high authorities are connected. Petitions for permission of organising telephone companies for exchange systems are made from time to time, but the Government does not permit it for some reason or other which I cannot tell. I believe, however, it will be permitted sooner or later.

Now, as regards electric lighting, we have the Brush arc lights in some factories, mills, and dockyards, and the Edison incandescent lights in some places, and among others may be mentioned 500 lamps in the Osaka cotton mill, and 330 in the Imperial Military College.

On many occasions, such as at the ball of the Minister of Foreign Affairs department, on His Majesty the Emperor's birthday, November 3rd, at the opening ceremony of the bankers' meeting place, and the like, we put up temporary plants with good success, and the result of this, together with the most satisfactory reports on the Edison incandescent lighting in the Osaka cotton mill and the *Official Gazette* printing office, induced our people to favour electric lighting with great eagerness. The Tokio Electric Light Company, which was organised some time ago, and of which Mr. S. Yashima (now in this room) is the president, has a capital of $200,000, and by the end of this year this capital stock will be doubled. The company has in hand the contract of lighting the new imperial palace with 2,000 incandescent lamps and 100 arc lights from the company's central station, located just outside the palace ground, and from which the current will also be supplied to the residences of the princes and ministers, and other houses around it. It is proposed to place five or more central stations in the city of Tokio, two in Osaka, one in Kioto, two in Nagoya, and in other places. Considering the facts that the City of Tokio is ten miles square, with a population of 1,000,000, and that there is now only one gas company, charging $2.50 per 1,000 cubic feet of gas, and having old fashioned gas furnaces, the Tokio Electric Light Company has a great deal to do towards the illumination of the city.

In conclusion, as there are many printing offices and small factories all over the city using at present foot-power or steam engines ranging from ¼ to 20 horse-power, the electro-motors will also, without doubt, find good places there. I hope, gentlemen, I shall be able to read a better paper when I see you next time.

* Paper read before the National Electric Light Association, Philadelphia, February 17th, 1887.

ON FROELICH'S THEORY OF COMPOUND DYNAMOS.*

BY KARL ZICKLER.

(Concluded from page 370.)

Result of Experiments with the Shunt Coils only in Circuit.

The connection with the shunt was again broken at the brush B (Fig. 1), and one of the external leads previously attached to the binding screws K, K′ was connected with the brush B, the

* *Zeitschrift für Electrotechnik*, Vol. V., Feb., 1887.

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other end being connected with the now free end of the shunt, so that the shunt coils, the armature coils, and the external circuit were all connected in series.

Tables IV. and V. give the results obtained in the same way as before :—

TABLE IV. (v=1165.)

No.	C	Δ	r	W	E_n	$\frac{v}{W}$
1	1·31	0·65	0·49	70·62	92·4	16·49
2	1·05	10·60	10·09	80·22	84·2	14·52
3	0·93	14·00	15·05	85·18	79·2	13·68
4	0·83	16·60	20·00	90·13	74·8	12·92
5	0·68	19·80	29·12	99·25	67·5	11·73
6	0·54	21·00	38·88	109·01	58·9	10·68
7	0·29	16·20	55·86	125·99	36·5	9·24

TABLE V. (v=1270.)

No.	C	Δ	r	W	E_n	$\frac{v}{W}$
1	1·51	0·67	0·44	70·57	106·5	17·99
2	1·25	12·60	10·03	80·21	100·2	15·83
3	1·14	16·60	14·56	84·69	96·5	14·99
4	1·00	19·80	19·80	89·93	89·9	14·14
5	0·82	23·70	28·90	99·03	81·2	12·82
6	0·66	25·50	38·63	108·76	71·8	11·67
7	0·43	25·50	59·30	129·43	55·6	9·81

The great difference between the potential difference at the poles and the E.M.F. is due to the greatly increased resistance of the machine arranged in this way as a series dynamo, its value being now 69·69 + 0·21 = 69·90 ohms.

In this case the rectilinear portion of the current curve was found to begin with a current of about 0·6 amperes, and, therefore, in the determination of the constants a_n and b_n it was only necessary to exclude currents below 0·6 ampere, instead of below 6 amperes as in the former experiments.

The values obtained were—

For	$v=1165$	$a_n=6{\cdot}67$	$b_n=7{\cdot}57$
	$v=1270$	$a_n=6{\cdot}93$	$b_n=7{\cdot}25$
Means		$a_n=6{\cdot}8$	$b_n=7{\cdot}41$

The quantity $1/b=f$ is called by Frölich the "armature constant," as depending only on the armature; but Von Waltenhofen has shown* by experiments with a series dynamo that the quantity f can be made to assume quite different values by altering the arrangement of the electro magnets while the armature remains unaltered. The value of f obtained from these last experiments, viz.: $f_n=\frac{1}{b_n}=\frac{1}{7{\cdot}41}=0{\cdot}1349$ differs, though not very greatly, from the value 0·1160 obtained in the first set.

The results thus obtained for the two sets of coils separately give the means of testing Frölich's formula

$$1-M'=\frac{(1-M_d')\,(1-M_n')}{1-M_d'\,.\,M_n'} \quad . \quad . \quad . \quad (1)$$

for their combined magnetising effect, a formula of which Frölich himself has not given any direct experimental proof. Peukert has tested its accuracy by a separate investigation of a doubly wound arm of a magnet belonging to a constant E.M.F. machine;† but the author considers it a matter of importance to test its accuracy in the case of a complete machine, especially as various important conclusions may be drawn from it.

In order to determine as simply as possible the magnetic saturation due to a given exciting current through the combined sets of coils, the two separate saturation curves are drawn in Fig. 3, in which the upper row of figures along the axis of abscissæ refers to the curve M_d', and the lower row to the curve M_n'.

The equations from which these curves are constructed are obtained as follows:

By definition

$$M_d'=\frac{M_d}{\overline{M}_d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Substituting for M_d and $\overline{M}_d$ their values obtained from (3) and (4), we find

$$M'_d=\frac{b_d\,C}{a_d+b_d\,C} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

and therefore substituting for a_d and b_d their values previously determined,

$$M_d'=\frac{8{\cdot}62\,C}{60{\cdot}8+8{\cdot}62C} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

and similarly,

$$M'_n=\frac{M_n}{\overline{M}_n}=\frac{b_nC_n}{a_n+b_nC_n}=\frac{7{\cdot}41C_n}{6{\cdot}8+7{\cdot}41C_n} \quad . \quad . \quad (10)$$

where C_n is the current when the shunt coils are used alone.

The dotted portions of the curve are those for which the formula does not hold good.

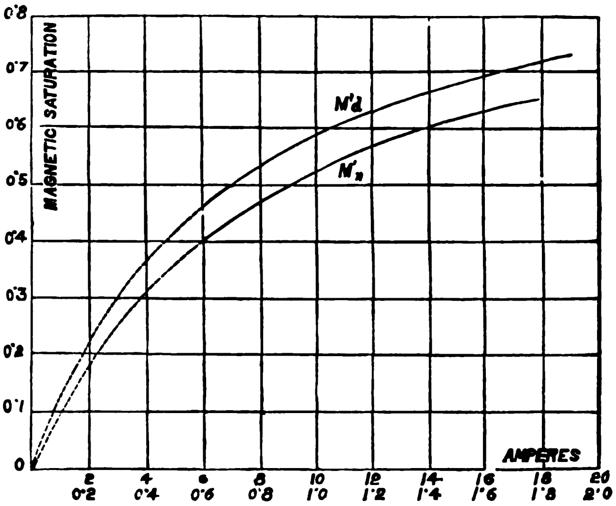

FIG. 3.

Tables VI. and VII. contain the results of experiments at the same two speeds as before, with the machine J L_3 connected up in the ordinary way according to the diagram (Fig. 1), and with varying external resistance.

TABLE VI.—(v=1165.)

No	C	Δ	r	C_n	E	M'_d	M'_n	M′	b	E′
1	19·0	102·9	5·41	1·60	115·51	0·729	0·636	0·8161	8·25	118·9
2	16·2	103·6	6·39	1·59	114·77	0·697	0·634	0·8003	8·12	116·2
3	14·2	103·8	7·31	1·58	112·65	0·665	0·632	0·7873	8·14	114·5
4	11·1	103·4	9·32	1·55	108·92	0·612	0·628	0·7656	8·11	111·3
5	10·1	103·4	10·24	1·54	109·76	0·589	0·627	0·7569	8·03	110·0
6	9·7	103·2	10·64	1·54	108·83	0·579	0·627	0·7531	8·04	109·5
7	8·8	103·3	11·75	1·53	108·76	0·559	0·625	0·7458	7·99	108·5
8	7·5	103·0	13·73	1·52	107·13	0·515	0·625	0·7318	7·96	106·4
9	6·8	102·5	15·07	1·51	106·66	0·491	0·622	0·7230	7·89	105·2
10	5·9	102·6	17·39	1·51	105·74	0·456	0·622	0·7130	7·86	103·7

TABLE VII.—(v=1270.)

No	C	Δ	r	C_n	E	M'_d	M'_n	M′	b	E′
1	16·9	112·8	6·67	1·71	124·15	0·704	0·651	0·8093	8·27	128·3
2	14·4	113·7	7·90	1·71	123·41	0·670	0·651	0·7957	8·18	126·1
3	11·5	114·2	9·93	1·71	122·02	0·619	0·651	0·7773	8·09	123·2
4	8·1	114·2	14·09	1·69	119·81	0·535	0·648	0·7495	7·95	118·8
5	7·3	114·3	15·69	1·68	119·39	0·509	0·647	0·7416	7·89	117·6
6	6·0	114·0	19·00	1·67	118·25	0·460	0·645	0·7275	7·81	115·4

* Einige Bemerkungen über die Frölichsche Theorie der dynamoelektrischen Maschinen, in the *Zeitschrift für Electrotechnik*, 1886.

† "Ueber die Berechnung der Electromagnete bei Compound Maschinen," in the *Zeitschrift für Electrotechnik*, 1886.

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Here, as before, C and Δ were measured by means of a torsion galvanometer, and the external resistance r is obtained as the quotient of Δ and C.

As the machine under consideration is one of constant E.M.F., with its shunt coils parallel to the armature, therefore the external current C is identical with the current flowing through the series coils.

The current in the shunt coils is obtained from the equator

$$C_n = \frac{\Delta + C r_d}{r_n} \quad . \quad . \quad . \quad . \quad (11)$$

by substituting for r_d (the resistance of the series coils) and r_n (the resistance of the shunt coils) their known values.

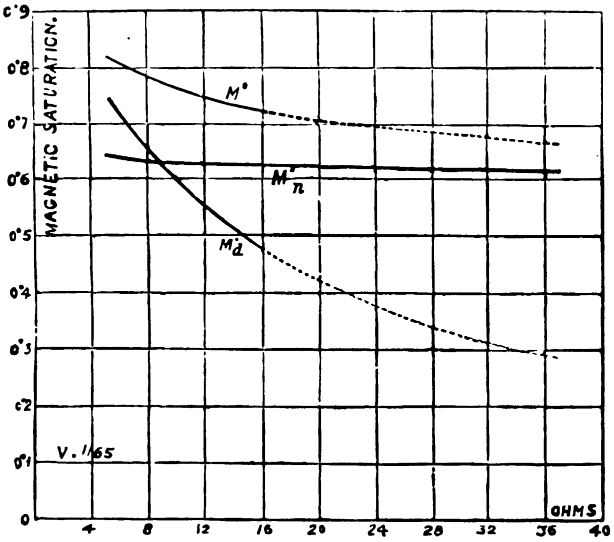


FIG. 4.

The small change in the current through the shunt coils corresponding to changes in the current through the series coils is noteworthy; it only alters by about 5 per cent., for example, when the resistance of the external circuit is trebled.

Knowing the values of C and C_n, the corresponding value of the magnetic saturation can be determined and interpolated in the columns M_d' and M_n', and the corresponding values of M' can then be found by means of formula (1). The values of M' given in Tables VI. and VII. show a very high magnetic saturation (over 80 per cent.), which would have been still higher if the machine had been worked with its full load.

Fig. 4 shows graphically how M', M_n' and M' vary with the resistance in the circuit, the continuous lines representing, as before, the portions which may be considered as accurate, according to Frölich's theory, and they show the following important facts:—

1. For a dynamo of constant E.M.F. the curve of relative magnetism (with regard to the external resistance) shows a steep inclination in the case of the series coils, while the curve corresponding to the shunt coils is nearly parallel to the axis of abscissæ.

2. With strong currents (in the present case up to 11·7 amperes) the series coils are chiefly effective, but for weak currents the shunt coils.

The values of E given in Tables VI. and VII. are obtained from the equation

$$E = \Delta \left\{ 1 + \frac{r_a + r_d}{r} + \frac{r_a (r_d + r)}{r_n \cdot r} \right\} \quad . \quad . \quad . \quad (12)$$

while E' is obtained from M' as follows:—

It is known* that the relation between the relative magnetism and the E.M.F. produced by it through the action of the separate sets of coils is expressed by equations of the form—

$$M_d' = \frac{b_d E_d}{v}; \quad M_n' = \frac{b_n E_n}{v};$$

A similar equation will hold in the case of the combined action of the two sets of coils, so that we may write

$$M' = \frac{b E}{v} \text{ or } b = \frac{v M'}{E}$$

from which b may be determined by the aid of Tables VI. and VII. Its mean value is found to be 8·035, which, as was to be expected, agrees very closely with the arithmetic mean of b_d and b_n,

viz., $$\frac{b_d + b_n}{2} = \frac{8 \cdot 62 + 7 \cdot 41}{2} = 8 \cdot 01$$

Using the latter value to determine the values of E', these are obtained from the equation

$$E' = \frac{v M'}{8 \cdot 01}$$

The agreement between the values of E and E' is very satisfactory (the greatest deviation being only 3·3 per cent.), especially considering that in equation (12), by which the values of E were determined, the resistances of the separate parts of the dynamo were assumed to remain constant in spite of the great variation in the strength of the current.

We conclude, therefore, that we are justified in taking as the value of b for the constant E.M.F. dynamo, the arithmetic mean of its values for the separate sets of coils, and also that the validity of the fundamental formula (1) is established.

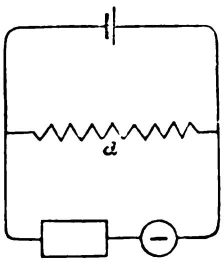
* *See* "Einige Bemerkungen über die Frölich'sche Theorie der Dynamo-elektrischen Maschinen," by A. von Waltenhofen, in the *Zeitschrift für Electrotechnik*, 1886.

BATTERY RESISTANCE.

H. R. Ottesen writes in the *Electrotechnische Zeitschrift*:—

The internal resistance of a battery is usually determined by the Wheatstone bridge method with alternating currents, or by the methods of Mance or Siemens. The first two of these were used to check the accuracy of the method here described. It is only applicable when the E.M.F. may be assumed to be constant.

In addition to the torsion galvanometer and its accompanying box of resistance coils, two known resistances, a_1 and a_2 (as, for example, one of 1 ohm and one of 0·5 ohm), which allow the current to pass without any resultant change in the resistance. The battery is short-circuited, first through one of the resistances a and then through the other, while the torsion galvanometer and its resistance box are placed in a shunt circuit, as shown in the diagram. Let E be the E.M.F. of the battery, r its internal resistance, C the strength of the current in the main circuit, c the current in the shunt circuit, and b its resistance (*i.e.* the combined resistance of the galvanometer and resistance box, which in these experiments had the values 1 ohm and 99 ohms respectively, giving for b the value 100 ohms).



Then for each value of a we have (assuming E to remain constant)

$$c = C \frac{a}{a+b}; \quad C = \frac{E}{r + \frac{a b}{a+b}},$$

or if we write $a b / (a+b) = R$, we have

$$C_1 = \frac{E}{r + R_1}; \quad C_2 = \frac{E}{r + R_2};$$

and, therefore, $$\frac{C_1}{C_2} = \frac{r + R_2}{r + R_1};$$

or, $$C_1 r + C_1 R_1 = C_2 r + C_2 R_2.$$

So that $$r = \frac{C_2 R_2 - C_1 R_1}{C_1 - C_2}.$$

The following table gives the result of some measurements made by this method, together with the values obtained by Mance's method and the Bridge method respectively:—

	Bunsen Cell.	Daniell Cell.	Clamond Thermo-pile.	Smee Cell.
Mance's method	0·058	0·606	0·485	0·177
Bridge method..................	0·051	0·606	0·485	0·150
Torsion galvanometer.........	0·053	0·620	0·464	0·150

The method is a convenient one for the determination of the resistance of the earth-contact of a lightning conductor when the E.M.F., due to the moisture of the soil, prevents the determination by means of a constant current, and it is also useful for determining the resistance of dynamos while actually working.

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PLANS FOR INSTALLING.*

BY MR. A. F. UPTON.

Central Stations.

It is not intended in this paper to consider the subject of electricity or of electric lighting, except in such manner as pertains to the erection, equipping, and running of central stations, either for arc or incandescent lighting, transmission of power, or for street railways, and to the economical production of power for these purposes I wish to call your special attention. When we take a retrospective view of electric lighting, and consider the advancement made since 1879, it is astonishing to recall the fact that at that time there was not in existence in the whole world a central station for electric lighting. In 1878 the Brush Company made experimental tests at the Mechanics' Fair in Boston, and in 1880 they started their first central station in New York, which was followed by others in Albany, Baltimore, Cleveland, Boston, &c. To-day there is scarcely a city or town of 20,000 inhabitants in the entire country which has not a central station either for arc or incandescent lighting, and in many instances towns with a population of from 3,000 to 4,000 are supporting an electric lighting business.

In starting a central station the first matter to decide upon is a proper location, and this requires the consideration of a number of important questions, among which are convenience for coal and water supply and a location central to the lighting area. The site having been determined upon, the next question to be considered is the character of the building; brick would of course be preferable for both the boiler house and machinery building, but ordinarily the engine and dynamo rooms are constructed of wood and the boiler house of brick. In either case allowance should be made for increase of plant in the primary structures and also sufficient land for increase of station buildings; for the inevitable necessity of this electric lighting business is to increase the plant, and the great mistake made by the pioneers of the industry has been in not allowing for this increase. Size of buildings must be governed to a certain extent by the size of the city or town in which the station is to be located, but for an ordinary plant we find the following dimensions well adapted for the purpose; and our company has recently erected a station of these dimensions, which is spoken of as a model plant. The main building is of wood, two stories in height, with brick wall next to boiler house, and is 80ft. long by 36ft. wide; the dynamo and engine room is 16ft. in height in the the clear, and the upper story (14ft. in the clear) is arranged to let power for manufacturing purposes if desired. The boiler house is of brick, 40ft. by 40ft. and 20ft in height, allowing of nearly 10ft. between the boilers and roof, and in addition there is a large ventilator in the roof. This plant starts with one tubular boiler, 6ft. by 16ft., with ample room for two more of the same size, and with proper passages at sides and rear of the boilers, and a 16ft. firing space in front, well paved with brick. For a chimney they use an iron stack 70ft. in height, 42in. in diameter at the base, and enlarging to 48in. at the top; this stack being of size sufficient for another boiler. They have one high-speed engine belting direct to the dynamos (one belt from each pulley of the engine), and with room for five more, which will be put in as needed. This plant is arranged for both arc and incandescent lighting, also to furnish power for an electric railway, and, when fully equipped, will easily develop 400 horse-power. There is also land sufficient to duplicate this plant. Starting on the basis that the manufacture or production of electric light was, in reality, merely selling power, we made it our aim to so equip these electric lighting stations to use such apparatus and fuel as would obtain the greatest amount of steam at the least possible cost, and to avoid as far as possible all loss between the boilers and dynamos.

The tubular boiler seems to be the standard among the electric stations, though many of the sectional boilers, especially the modern ones, have advantages well worthy of consideration.

On the basis of tubular boilers, we say, without reserve, put in steel every time; do not be satisfied with homogeneous steel which can cover anything known as steel, but have specifications on flange or, better still, of fire-box steel of some good brand. For the heads use flange steel. Do not put in a small boiler; a good 6ft. tubular costs but little more, takes up but a little more room, and the setting is but slightly more expensive than a 5ft., while the capacity is almost double. In putting in the foundations of the boiler setting, put them in for two boilers; they will be needed later, and such work is inconvenient when running a station.

We say, as a matter of course, set the boilers on the Jarvis furnace and use the cheapest fuels you can buy. Let the projectors of any electric business take the trouble to investigate in their locality and see what cheap fuel can be procured; it is generally safe to say that they will find either slack coal, screenings, sawdust, wet tan, coke-screenings or similar refuse fuel, and every such opportunity should be taken advantage of. The question in selling electric lights is not how many pounds of coal per horse-power, but rather what is your cost per light. How many pounds of water can you evaporate from your boilers for one dollar's worth of fuel?

On the point of economy among the Edison stations, where Mr. J. H. Vail, their general superintendent, has perfected a system of records from all their stations, by which accurate comparisons may be made, it is worthy of note that the highest stations on the list have their boilers set on the Jarvis furnace, and, using cheap fuels, the same result is being shown among the Thomson-Houston companies, where a similar plan is being adopted. In setting the first boiler, build one outside wall as the middle wall for a second boiler; it is also wisdom to put in an iron stack (if iron is used) large enough for two boilers, and the first cost of a pump, heater, and injector large enough for two boilers is but little more than for one. For feeding the boilers we advise using both a pump and injector, using the pump in connection with a heater when the engine is running, and having the injector as a reserve feed, also to use to furnish the boiler with hot water in case the engine is not running. For boiler fittings we consider that a nickel seat pop safety valve is none too good, and it is very poor economy to attempt to save a few dollars at the expense of safety. A cheap set of grate bars is sure to prove the dearest in the end of anything about the entire plant; it costs more at first to put in a set of first class rocking grates, or of stationary grates, but continous running expenses are to be considered fully as much as first cost, and, to judge the future by the past, these companies which do not have their plants equipped in a manner to produce low-cost power will be obliged either to remodel their plants or be forced to the wall by the active competition which is springing up among the different systems.

To consider briefly the question of engines, I will state that we were the first to adopt what has since become almost the standard for successful electric lighting stations—the system of using small high-speed engines belting direct to the dynamos. We had experience first with the long-stroke engines, and were very soon satisfied, from the many objections arising, that some different plan must be substituted. In the first place, the friction of the large engines, necessitating the use of shafting, together with loss due to the extra belting, is nearly double what is shown to be the practice in running the small engines. Again, if it is desired to run a small number of lights, it is a waste of power to run an engine greatly out of proportion to the work. It is the case in many stations where the commercial lights are on a different circuit from the street lighting, that they are obliged to start and run a large engine from one-half to three-quarters of an hour just for a few commercial lights, while, by the use of a small engine, the load could be adapted for the store lights and the main lighting put on as required, and when time to cut out the store lighting, it is only necessary to shut down the engine running that circuit, and stop all expense pertaining to it. If an engine gives out, the whole of the lighting is not stopped, as would be the case in the use of one large engine; and, in a station using a number of small engines one reserve engine is practically a duplication of the engine-power. Referring to the economy of these small engines, I will read an extract from a report of a recent test made by Prof. Thurston at the station of the Narragansett Electric Lighting Company, at Providence, using A. and S. engines of 50 horse-power each and lamps of 2,000 candle-power. He reports as follows:—"When the engine was running without load, the steam consumption was 26·2 pounds per hour and per horse-power; when driving the dynamo alone, 25·6; when 25 lights were on, 21·3; when 50 lights were on the consumption was, according to the cards, 21·5 pounds. The economy of driving direct to the dynamo without intervention of countershafts is well shown by these trials. The expenditure of power was, in this case, but seven-tenths of a horse-power per light when fully loaded, while the power demanded when a countershaft is used is often reported to be 25 or 30 per cent. higher. With 60 lights in the circuit the power expended was, in this case, just 0·7 horse-power per light." The Armington and Sims engines, of which we act as selling agents, are made of both types; double disc engines with two wheels, arranged to belt direct to dynamos, and also single disc, with which it is necessary to use shafting; and the results of our extended experience have been such that I do not hesitate to say that we do not consider that a station with shafting can compete with any degree of success with one equipped to belt direct. In piping from the boilers to the engines, we place valves so that neither boiler nor engine may be shut down without interfering with the running of the balance of the plant; and in piping the primary portion of the plant we put in the main steam and exhaust as near what the ultimate capacity of the station would require as can be determined. We also provide a muffling tank for the exhaust where there is any question of the noise of the exhaust being the cause of trouble.

Combustion.—The subject of combustion of fuel is of sufficient importance among the electric light people to merit a few general remarks on the matter, and it is a subject that is far less understood by steam users than any one would suppose, considering the cost of the fuel consumed in making the steam in this country, and the following facts should interest all parties using steam power:—1st. That coal is distilled into gas before it can be properly burned. 2nd. That to burn this gas, a sufficient supply of hot air must be introduced at a temperature not low enough to cool the gases below their igniting point. 3rd. Every time a lot of fresh coal is thrown on the fire a great production of gas occurs, and if it is to burn to a flame it must have a corresponding supply of hot air. After a time, when the mass of fuel has become red hot, the supply of gas is greatly diminished, but at first the evolution of gas actually checks the draught; but bear in mind that, although no smoke may be visible from the fire, it by no means follows that its combustion is perfect; if you diminish the supply of hot air, or reduce the air-space of your grate bars, you will be merely distilling carbonic oxide gas up the chimney. 4th. In ordinary boiler furnaces there is an insufficient supply of air; fresh coal is put on the grates, and the firing doors are closed; gas is being distilled from this coal. Now, if you do not furnish air above the fire (and it must be hot enough to ignite the gas), how can you expect to get combustion? Whether it is expected or not, it does not burn properly, and your boiler furnace is nothing more than as a gas retort in a gas works, making crude gas and wasting it up the chimney; in other words, a first class soot and smoke factory. Therein we claim the principle of the Jarvis furnace to be correct; it does furnish pre-heated air to ignite and consume these gases, and make flame and heat otherwise wasted in the chimney; and, further, it allows of the use of fuel or a class of fuels that in an ordinary furnace will produce little else than soot and smoke.

Smoke Burning.—As most boiler furnaces are constructed they are nothing else but gas producers—that is, all gas producers are extra bad stoves or boiler furnaces. Consider how ordinary gas is made; there

* Paper read before the National Electric Light Association of the United States.

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is a red hot retort or cylinder, into which you shovel a quantity of coal, which flames and smokes vigorously as long as the door is open; when it is full of coal you shut the door, cutting off the supply of air, and extinguishing the flame. Gas is now simply distilled, and passes along pipes to be purified and stored. You perceive at once that the difference between a gas retort and an ordinary boiler furnace with closed doors and half-choked grate bars is not very great. Consumption of smoke, using bituminous coal: It is not a so-called "smoke burner" you really want, it is a fuel consumer. You distil your fuel instead of burning it in nine-tenths of your boiler furnaces. There is no such thing as "burning smoke." Once made, it cannot be burnt, and the only way I know of burning it is not to make it.

Air Feed.—The question of supplying hot air, and the amount to be supplied at the right time, is a question that has puzzled the most scientific men who have made a study of this most important question. The Jarvis furnace is so constructed that the damper regulates the amount of air delivered into the boiler; if the full force of the draught of the chimney is required, then the open damper allows a full supply; a half damper gives one half the supply, and if the damper is closed no air enters the furnace over the fire. Every first-class steam plant should use a steam damper, and with such a damper the feed of hot air is perfectly automatic. The Jarvis furnace for setting steam boilers is constructed in the following manner:—It is the same principle as the Siemens-Martin furnace for making steel. In a different manner, and on a smaller scale, we pre-heat air (oxygen) and discharge it over and back of the fires, thus utilising and igniting gases generally wasted. The joining of hot air with gases creates a draft and allows the combustion of low grade fuels that would otherwise require a draft to burn. Smoke is reduced to a minimum by this process. If the fuel is wet it is an advantage where hot air is used. The principal thing to my mind in regard to electric lighting is the cost of power. I have always claimed from our experience that the matter of power in this regard was figured in one sense on a wrong basis. My idea is to get at the bottom of all economy in electric lighting; the cost of power should be most carefully looked at. The only thing to be considered is the actual cost per lamp per hour, not evaporation of pounds of coal per hour. It is the actual cost of running an incandescent or arc lamp per hour. The only money to be made in the future in electric lighting under the coming competition is to be made in saving. Reduce the cost of fuel, use only the cheapest and lowest cost grades. Why use the highest cost coal when slack coal, screenings, or pea coal can be purchased at one-half price, and with proper furnaces evaporate the same amount of water as the highest grades of coal? Such, in general, is my idea of what would be the best and most economical for an electric lighting station, and which is well shown in the blue prints. Should any member desire one of the prints we will be pleased to furnish it. We have equipped some stations under conditions which required a great deal of ingenuity to accommodate a given power in limited room, of which the Edison Central Station of Boston is a striking case of what can be done. I have a full set of blue prints of that station, and it may interest some of the members to listen to a general description of what has been done there. I will say, respecting this station and these plans, that although we did the work of fitting out the station, the design work and plans were made by and done under the supervision of the engineering department of the Edison Company, and I am indebted to Mr. J. H. Vail, general superintendent of that company, for his courtesy in furnishing the prints and allowing me to exhibit them.

GERMAN UNION TELEGRAPH AND TRUST COMPANY (LIMITED).

Report of the Directors, to be presented to the sixteenth ordinary general meeting of shareholders, to be held at the offices of the Company, Winchester House, Old Broad-street, E.C., on Monday, the 21st inst., at twelve o'clock:—

The total receipts during the twelve months amount to £13,113 6s. 8d., which, with a balance of £12. 7s. 1d. brought forward from last account, make a total of £13,125. 13s. 9d. The expenses for the same period amount to £794. 18s. 10d. Of this sum £750 is provided by the German Union Company of Berlin. Out of the receipts an interim dividend of 5s. 9d. per share was distributed on the 14th January last, and the Directors recommend the payment of a further dividend of 6s. 3d. per share, making a total distribution for the year of 12s. per share, free of income-tax, or at the rate of £6 per cent. per annum (as against £5 paid last year), leaving a balance of £30. 14s. 11d. to be carried over to next account. The cables are in good working order; the traffic, which had a considerable increase last year, has been regularly carried on without any interruption. The low cable rates for the Atlantic messages have, since May last, led to a large augmentation of traffic over the German Union system, to the extent of about 114 per cent., and as the Berlin Company have secured to them by their agreements a minimum tariff for their line, they are necessarily placed in a privileged position as compared with other transatlantic companies, and will continue to profit by the increased business which low rates have brought about. The establishment of a repeating or relay station at Lowestoft has answered the expectations formed of it, and has led to very efficient working arrangements. On the occasion of the remarkable interruption of the land wires in England on the 26th December last the Berlin Company was able to be of signal use in carrying on the traffic between the Continent and this country, when all other routes were temporarily interrupted. The renewal fund and reserve fund of the Berlin Company now amount to £67,738. Their capital is £330,000. According to the Articles of Association Sir James Anderson, one of the Directors of the Company, retires by rotation, and offers himself for re-election. The auditor, Mr. Henry Dever, also retires, and offers himself for re-election.

CITY NOTES.

EASTERN TELEGRAPH COMPANY.—The company announce the payment on the 14th April next of a dividend of 3s. per share on the preference shares of the company, less income-tax, for the quarter ending March 31st, 1887, and an interim dividend of 2s. 6d. per share on the ordinary shares of the company, free of income-tax, in respect of profits for the quarter ended 31st December, 1886. The company's register of transfers will be closed from the 8th to 14th April next, both days inclusive.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—The accounts of this company to the 31st December last, show, subject to audit, a balance of profit of £94,800, after payment of three interim dividends. The directors now propose, subject to the approval of the shareholders, to pay on the 28th April next a dividend of 2s. 6d. per share for the quarter ended 31st December, together with a bonus of 2s. per share (both free of income-tax), making, with previous distributions, a total payment of 6 per cent. for the year 1886. The balance of £38,550 has been carried to the reserve fund, which, after being debited with the cost of the Singapore-Penang (renewal) cable, now stands at £569,440.—The company also give notice that the third drawing for payment of their Five per Cent. Debentures (1880 issue)—108 in number—will take place on Wednesday, the 30th inst., at 11:30, at the company's offices, 50 Old Broad-street, E.C. Further particulars will be found in our advertisement columns.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 11th March were £3,403, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 11th March amounted to £4,215.

DISSOLUTION OF PARTNERSHIP, &c.—We are informed that the partnership previously existing between Messrs. Barker and Miller, electricians and chemists, of Turnmill-street, has been dissolved, and that Mr. Barker, who has lately moved into larger premises at 79, Turnmill-street, continues to conduct the business.—Messrs. Price, Sons and Co., of Bristol, whom Mr. Barker has so long represented in London, have also secured large show rooms at the same address.

REMOVAL.—The Æolus Waterspray General Ventilating and Electrical Engineering Company have removed from 235, High Holborn to 124, High Holborn.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. March 16.		Business Done Week Ending March 16. Highest.	Lowest.
Anglo-American	32,	33	32½	31
Do. Preferred	53,	54	54	53
Do. Deferred	12½,	13½	13½	12
Brazilian Submarine	10½,	10¾	11	10⅝
Cuba	11½,	12	11⅞	
Do. Preference	18,	19	-	—
Direct Spanish	2,	2½	2	—
Do. Preference	7,	8	—	—
Direct United States Cable	8¼,	8½	—	—
Eastern Telegraph	10⅜,	10⅞	10¾	10⅜
Do. 6 per Cent. Preference	13,	14	13¾	13 9-16
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	11⅜,	11⅞	11¾	11⅜
German Union	8¾,	9¼	9¼	9⅛
Globe Telegraph and Trust	4⅞,	5⅛	5	4⅞
Do. Preference	12,	12½	12½	11 15-16
Great Northern	13½,	13¾	13 13-16	13⅝
Indo-European	35,	36	—	—
Reuter's	6¾,	7¼	—	—
Submarine	185,	195	190	185 xd.
West India and Panama	⅝,	⅞	11-16	—
Do. 1st Preference	8¾,	9¼	9¼	9
Western Brazilian	7⅛,	7⅝	7⅜	7 5-16 xd.
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	100,	102	103	— xd.

TELEPHONES.

Consolid. Telephone and Maintenance	¾,	⅞	—	—
Oriental	3-16,	5-16	—	—
United Telephone	12,	12½	12⅝	12

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	2½	—
Do. (fully paid)	3¾,	4¼	4¼	3⅞
Swan	1⅜,	1⅝	1½	—
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	35½,	37½	38½	37⅝ xd.
India Rubber, Gutta Percha, and Telegraph Works	22,	23	22½	22 xd.

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NOTES.

INTERRUPTION OF CABLE.—We learn that the cable between Trinidad and Demerara is interrupted.

LYONS.—It is significant to observe that the gas company of Lyons has applied to the municipality for permission to replace gas by electric light in some of the principal streets of that city.

CENTRAL INSTITUTE CONVERSAZIONE.—It was rather too unkind to select for the ladies' cloak (and beautifying) room, on Thursday, one which bore the inscription, "Chemical Preparation Room."

SOCIETY OF ARTS.—The paper by Mr. Reckenzaun on "Electric Locomotion," which was announced to be read at the Society of Arts on Wednesday, March 30th, has been postponed until after Easter.

THE PARIS-BRUSSELS TELEPHONE LINE.—Up to the present time the average number of communications per day upon the Paris-Brussels telephone line has amounted to sixty. This is considered satisfactory.

THE TRANSMISSION OF POWER.—At Worcester, Mass., where an Exhibition has just been opened, the whole of the moving machinery is operated by electric-motors, supplied with current from a central station, on the "Daft" system.

ELECTRIC LIGHTING TENDERS ASKED FOR.—We call attention to advertisements which will be found in another column, asking for tenders for lighting the new Municipal Buildings at Glasgow, and also for lighting a warehouse in Edinburgh.

THE SCHONSCHIEFF BATTERY.—It is stated that M. Schonschieff has succeeded in effecting certain improvements in his single fluid, sulphate of mercury cell, with the result that a horse-power-hour is now obtained for each 220lb. dead weight of the battery.

LIÉGE.—At Liége a new building erected as a museum and fine art gallery is to be lit by arc lamps by M. Pieper. We also learn that the Electric and Hydraulic Company of Charleroi has obtained a contract for lighting the public park of this city in the same manner.

INTER-URBAN TELEPHONY IN FRANCE.—The French Ministry of Posts and Telegraphs has recently made very large purchases of silicium-bronze wire, and it is rumoured that this is in connection with an extensive scheme for long-distance telephony which will shortly be announced.

THE EXHIBITION AT NEWCASTLE-ON-TYNE.—The electrical transmission of power will form one of the most important features of the forthcoming Exhibition at Newcastle-on-Tyne. A great deal of the machinery in motion will be driven by electro-motors, and there will also be a telpher line in operation.

CHATEAULIN, FINISTERRE.—On Sunday last a central station supplying light to the chief streets, the public buildings, and many private houses at Chateaulin, Finisterre, was inaugurated by the Maire of the Commune. The work has been carried out by M. Ernest Lany. Power is obtained from a stream at a distance of 2 miles from the town.

RAHERE CLUB.—On Monday evening the Rev. Pelham Ogle, of St. Bartholomew-the-Great, delivered a lecture, illustrated by experiments, on "The Mariner's Compass." The principal facts of magnetism, and the connection between magnetism and electricity were expounded. The instruments used were mainly lent for the purpose by Messrs. Orme and Co., of Barbican.

"TECHNICAL SCHOOL AND COLLEGE BUILDINGS."—Messrs. Whittaker announce for early publication a comprehensive reference book on "Technical School and College Buildings," by E. C. Robins, F.S.A., whose special acquaintance with this subject has been the result of English and foreign travel, research, and careful comparison of modern examples at home and abroad. The work is to comprise 250 quarto pages with 114 illustrations.

TELEPHONES ON THE CONTINENT.—According to an Exchange Company's telegram dated Brussels, March 23rd, the Edison Gower-Bell Telephone Company, of London, have brought an action against all the Belgian telephone companies before the Courts of Brussels, Antwerp, Namur, Liége, and Louvain for counterfeiting the Edison telephone system, the patent of which belongs to the aforesaid company. The hearing of the action will shortly take place.

ELECTRICAL COMMUNICATION WITH LIGHT VESSELS.—A meeting of the committee appointed to consider the subject of electrical communication between lightships and the shore was held at the offices of the Board of Trade on Saturday last. The Earl of Crawford presided. Evidence was given by Mr. Emmerson, superintendent of Trinity House for the Great Yarmouth district; Mr. Whitby, mate of the St. Nicholas light vessel; Mr. Jenkins, mate of the Gull light vessel; and Captain Glover, Harwich.

THE UPWARD BATTERY.—The new form of Mr. Upward's chlorine battery, which we described and illustrated in our issue of the 25th February, is now in use for lighting some offices at 11, Queen Victoria-street, where Messrs. Woodhouse and Rawson will, we believe, be pleased to show it to any one interested. We may add that the clockwork switch arrangement, as to the practicability of which some degree of scepticism has prevailed, does seem certainly, so far as we have yet been able to gather, to perform its duties in a thoroughly satisfactory manner.

THE PHYSICAL SOCIETY.—We would call the attention of our readers to the report of the last meeting of the Physical Society, which will be found in another column, and at which several short papers of a particularly interesting character were read and discussed. The phenomenon detected by Mr. Shelford Bidwell of the existence of a differential resistance in wires undergoing strain according to the relative direction of the current is both new and from a theoretical point of view important. It would be interesting to know whether any theoretical reason can be advanced for the reversal of the effect in iron.

THE COWLES ELECTRIC SMELTING COMPANY.—The Cowles Electric Smelting and Aluminium Company, of Cleveland, O., are now exhibiting what they call aluminium steel. In a sample bar of iron welded to a bar of Siemens-Martin basic steel, with one-fifth of 1 per cent. of aluminium added, no line of weld can be seen, the characteristics of the steel appearing to extend far into the iron. Without the aluminium a clearly defined weld is visible between iron and the same steel. The same firm show a forged bar of aluminium bronze, with 5 per cent. of aluminium. This broke at 36 tons per square inch of original section, with 60 per cent. elongation.

AURORA.—During the past month, we learn from *Nature*, there have been several fine displays of the aurora borealis in Northern Sweden. The displays generally began about 8 p.m., and continued till towards midnight, the point of culmination being reached about 11 o'clock. The aurora appeared in the form both of streamers and clouds, the colours being mostly white and yellow. With respect to the development of the

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true and complete theory of the aurora, a highly important observation has been made by M. Lemstrom, who points out that in all regions of the earth the frequency and brilliancy of auroral displays bear an inverse ratio to the number and intensity of thunderstorms.

GERMAN PATENT LAW.—The Court of Appeal at Leipzig has recently enforced a decision annulling several patents taken out in Germany by American inventors on account of the apparatus described not having been manufactured in Germany within the prescribed time. A similar law holds good in France, and is no doubt in accordance with the protectionist policy of these countries; but in the great majority of cases it fails to effect its purpose of creating the establishment of works and factories within the frontiers of the State. So far as regards France, at any rate, it is, we believe, usually sufficient to put the last touches to a single example of the apparatus in question on French soil in order to obtain the required certificate.

THE BRAY ELECTRIC TRAMWAY SCHEME.—The Bray Township Commissioners met last week to consider the scheme, for which Parliamentary powers have been obtained, for the construction of an electric tramway between the town of Bray and the bathing station of Bray Head. The scheme was approved by a considerable majority, only two members of the Board voting against it. But unfortunately the proceedings did not terminate at this point. It appears that after the resolution had been carried the large body of car owners who were present represented the danger which might be expected to ensue from the spirited horses they are accustomed to drive being frightened by the self-propelling vehicles. In the end it was agreed, in characteristically Irish fashion, that the "electric" tramway is to be worked for the present by horses; but that at the end of two years the electricians are to be given another chance.

EDINBURGH TELEGRAPH CLERKS AND PROMOTION.—A meeting of Edinburgh telegraphists was held on Tuesday afternoon, at which it was stated that considerable dissatisfaction prevails in connection with a number of promotions recently made. It appears that fourteen second-class men had been appointed to the first-class, but in seven cases senior clerks had been passed over, and had thus been practically reduced. In one instance a clerk had been promoted over fourteen, another over eighteen, and a third had been raised over no fewer than 37 second-class men. As no reason has transpired for this official action, it was determined to ask the chief superintendent what qualifications are necessary before a clerk is entitled to a place in the first class. It was further decided to approach a member of Parliament, in order that the attention of the Postmaster-General may be drawn to the matter.

PROPOSED PUBLIC ELECTRIC LIGHTING BY THE MUNICIPALITY OF PARIS.—Notice has been given by a member of the Municipality of Paris to move the following resolution:—"A special commission of ten members, of which five are to be elected by the Municipality and five by the Prefectorate, shall be charged with the *immediate* consideration of the best means of establishing a municipal service of electric light in Paris. This commission shall, as soon as possible, present a scheme for the establishment of central stations both for lighting the public streets and private residences." We shall be glad to hear that the resolution has been carried; but we trust that the installations will not be subject to the rigorous (not to say ridiculous) conditions which have just been promulgated by the Prefect of Police with regard to the lighting of places of amusement in Paris. The full text of this remarkable edict will be found in another column.

THE TRANSMISSION OF POWER.—In reference to the account which appears in another column of an extensive scheme for the transmission of power in Spain, we may mention that a note which appeared on page 322 of our present volume had reference to the same project. If the scheme is carried out at all we shall be disappointed if it is placed in other than English hands, although we can quite understand that electricians would in general prefer to obtain a little more experience in the transmission of moderate forces before dealing with horse-power measured in three figures. We may add that inquiries are now being made as to the possibility of the transmission of energy on an equally large scale in a locality much nearer home, although we are not at present in a position to publish details.

LECTURE.—A lecture was delivered at Forest Hill, on the 17th inst., by Mr. W. Stepney Rawson, M.A., on the subject of "Light and its Various Modes of Production." The subject of radiant heat was touched upon and illustrated by a Forbes thermopile and galvanometer combined, made by Messrs. Nalder Brothers. Photometry was also explained—the newest form of pentane lamp of Mr. Vernon Harcourt being exhibited, and described as the most satisfactory form of the much-needed standard of light. The Welsbach incandescent gas lamp was also shown, the measured efficiency of which was stated to be over seven candles per cubic foot of gas per hour. These lamps and the numerous other apparatus illustrating the electric production of light were manufactured and supplied by the Woodhouse and Rawson Manufacturing Company. Several applications of incandescent lamps to scientific purposes were shown, and an explanation given of the working of the Upward primary battery in installations of domestic lighting, the simplicity of the working being much appreciated by the audience.

A NEW MAGNETO CURRENT GENERATOR.—M. Maiche is said to be constructing a magneto machine, in which the magnets are to revolve while the armature remains at rest, the object of this construction being to do away entirely with brushes and commutators. In appearance the new machine will resemble a Siemens alternating current dynamo; each of the armature coils is described as being connected with a separate and independent internal circuit, although it would not appear that this feature is essential to the design. It is difficult at first sight to conceive that any special value can attach to a machine of this description, in which, whatever may be the efficiency, the output per unit weight must necessarily be very small. It does, however, seem possible that if employed as a motor, the machine might prove distinctly valuable for use in coal mines, where objection is raised to ordinary motors on account of the danger from sparking at the brushes. We do not know whether or not this is the purpose which the inventor has in view, but we venture to suggest the idea for his consideration.

THE WEBER PHOTOMETER.—Prof. Weber has designed a photometer in which the standard of light is obtained from a benzine lamp, in which the wick is kept always at a constant height. In front of the lamp is a blackened tube, closed by a disc of ground glass, which can be adjusted in position within the tube. At the further end is a right-angled prism, by which the image of the disc is totally reflected through a second tube fixed at right angles to the first, but capable of motion in a vertical plane. The photometer is designed more especially for the comparison of the degree of illumination of

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surfaces, which is in fact of greater practical importance than the measurement of the intensity of the source of light. The adjustable tube is divided longitudinally into halves, and the operator directing it towards the surface whose degree of illumination is to be measured, sees side by side in the second half the image of the disc illuminated by the standard lamp. The disc is then shifted to and fro until the two halves are equally bright. The position of the disc as read upon a scale gives the relative candle-power. A slight modification enables the instrument also to be used for the direct measurement of the intensity of a source of light. The greatest degree of interest in Prof. Weber's instrument would attach to a description of the standard lamp and the trustworthiness of the results obtained with it; but upon these points we have no information.

THE PATENT LAW.—A Blue Book recently issued contains the report of the Committee appointed by the Board of Trade in 1885 to examine into the working of the Patents Act of 1883. No very important changes are recommended. It has, however, been demonstrated that the present system, whereby an applicant is supposed to receive notice of any anticipation of his invention which may still be pending in the form of a provisional specification, does not work well in practice. The notice of anticipation has to be issued upon the sole responsibility of the examiner, and the inventor is not permitted to examine the specification himself; consequently he has either to accept the views of the official examiner as final, or he has to risk his money by proceeding with the specification. The committee propose to rescind this rule altogether, but suggest that the inventor should be entitled to the return of his fees, if after the specification had been accepted it should prove that a prior application for the same invention was still pending. Another proposed alteration is to the effect that unless an amendment making the application conformable to the requirements of Section 6 be made within one month, the patent should date only from the time of the application being made so conformable, and not from the time of the original application. Section 6 provides for the return of the original specification if the examiner thinks that the description is not sufficiently clear.

HINTS FOR THE MANAGEMENT OF ELECTRICAL ACCUMULATORS.—Messrs. Anderson and Munro, of Glasgow, send us a small pamphlet written by Mr. J. Munro, and published under the above title. The directions contained in this little book are very clear and explicit, and such as should enable any intelligent workman to obtain sound ideas as to the proper treatment of accumulators. The author has taken care to confine his remarks to installations such as are commonly found in practice, and not to ideal examples in which the accessory fittings are assumed to have been undertaken without regard to expense. This manual may therefore be looked upon to some extent as supplementary to the more ambitious work of Sir David Salomons (of which, by the way, the second edition, published by Whittaker and Co., has just made its appearance). Sir David has usefully told us how a battery room should be equipped, and how the behaviour of the cells can best be studied both from a practical and scientific point of view. The present work, on the other hand, is intended primarily for the guidance and enlightenment of the man who is placed in charge of an engine, a dynamo, a battery, and a couple of measuring instruments, and has to make the installation go somehow. It must, however, be added that the directions are chiefly intended to apply to the cells of the Electrical Power Storage Company, and do not in all respects cover the requirements of cells of other makers.

DUPLEX WORKING OF SINGLE NEEDLE ON THE CALEDONIAN RAILWAY.—A correspondent sends us the following interesting note:—"The pressure of work upon telegraph circuits has not been limited to the postal telegraph service. Railway lines feel the pressure of traffic, especially in the summer, or tourist seasons, and this last year became so great as to raise the question whether running new wires, or finding some means of getting more work out of existing ones should be done. Such, at least, was the case with the Caledonian Railway Telegraph Department, and the matter was decided by experimentally trying whether the single needle, exclusively used by the railway, could be duplexed. The outcome of these experiments is that Mr. A. S. Dunn, the telegraph engineer of that company, has successfully fitted his Glasgow-Carlisle wire with differential coils and rheostats, whereby he is able to get double the work out of the circuits. Two intermediate stations remain in circuit, but have strict instructions not to touch the instruments unless they are called up. The practical working of the circuit is admirable and everything that can be desired. More recently, however, the absolute necessity for specially-wound and differentiated coils has been obviated, for it is found that the ordinary single needle coils can be operated for duplex workings by the simple act of attaching a wire from the line of the instrument to the back of the brass framework, where the current is split, and connecting up as for usual duplex workings. This latter fact will, no doubt, be taken full advantage of by other companies, as by this means duplexing single needle circuits can be accomplished with the most trifling cost."

AUSTRIAN TELEGRAPHS AND THE SNOWSTORM.—A correspondent sends us the following interesting letter from Vienna: "From Sunday, the 13th, to Tuesday, the 15th, a most violent snowstorm has been sweeping over Austria, stopping all the northern, the eastern, and the southern railway lines, and doing most damage in the south. The whole train communication to Trieste has been stopped, and will remain blocked for days to come. All State telegraph lines south have been swept away, except the one to Goriza, *viâ* the Tyrol. Thousands of double oak poles have been levelled to the ground along the Karzt, a wild mountain range dividing Styria from Trieste, on the route from Laibach to Trieste. Even the iron poles have, in many cases, been torn out of their sockets. The snow stuck to the wires, froze on, and formed one mass of ice and snow on them, and were thus levelled to the ground by the hurricane (Bora), which has this time done more damage than ever. Direct telegraphic communication to Trieste has been entirely stopped, and it will take weeks to get this right again. Telegrams to Trieste from here go either *viâ* Italy, Otranto-Corfu, and Corfu-Trieste, over the Eastern Telegraph Company's cable, or *viâ* Goriza (Goiz), and from there by sleigh and carriage to Trieste. Between Goiz and Trieste the snow lies frequently over five yards deep. All communication to Limne and Pola is stopped; the Austrian Government is therefore completely cut off from their only great naval arsenal and harbour. In the north-east great damage has also been done, but not so bad as in the south. The telephone network in Trieste with 400 subscribers has stood the brunt very well *Viâ* Goiz telegraphic information has been received, saying that all the town lines have remained intact, and only the outside lines to the new harbour and mountains have suffered, which proves the utility of bronze wires for overhead lines."

THE STUDY OF ELECTRO-TECHNICS.—At a meeting of the newly-formed "Syndicate Professionel des Industries Elec-

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triques," which is charged with the electric lighting of the International Exhibition to be held in Paris in 1889, M. P. Lemonnier took occasion to deliver an interesting address on the present condition of electro-technical education. He complained in strong terms of the backwardness of France in this important matter, and seeing that there does not at present exist in that country a single institution for the special study of electrical engineering, it must be admitted that the complaint is well founded. M. Lemonnier pointed to the increasing number of high-class technical schools and colleges in this country in which a special course of training for the electrical profession may be obtained, to the eight schools of electro-technics which already exist in Germany, and to the excellent work of a similar kind which is being done in Milan; but the speaker reserved his admiration chiefly for the Institut Electrotecnique Montefiore, which is affiliated to the University of Liége. In the year 1883 M. Montefiore offered to the Belgian Government the sum of 100,000fr. towards the establishment and endowment of a school of electro-technics at Liége. The institution, which has been placed under the direction of Prof. Eric Gerard, assisted by M. Zumini, is equipped with every appliance for theoretical study and practical training in electrical engineering. The students are divided into two classes:—(1) Those who are engaged in the regular curriculum of the University, and who select electrical science for their special study. For these students the course extends over three years. (2) Mechanical or civil engineers, not connected with the University, who desire to obtain a general acquaintance with the subject. For this class the course is completed within twelve months. M. Lemonnier concluded his address by moving a resolution to the effect that an urgent appeal should be made to the Government to found a similar institution in France.

PROBING BY ELECTRICITY.—At a recent meeting of the New York Academy of Medicine, Dr. J. H. Girdner read a paper on the methods of detecting and locating metallic masses in the human body by the induction balance and the telephonic probe. He referred to the apparatus which had been constructed by Prof. Bell for the purpose of locating the bullet in the case of President Garfield, and said that it had failed because at the time the patient was lying on a metallic mattress, which interfered with the working of the instrument. Now we have an apparatus which will detect and locate any piece of metal wherever situated in the human body. In the construction of the induction balance a bichromate battery is used, with six cells, and an ordinary interrupter, the interruptions being about six hundred to a minute. The exploring coils were put in a framework of wood, which Prof. Bell called the "explorer," while to the others the name "adjusting coils" was given. Thus, in the primary current were two coils, in the secondary current were also two coils, and in the circuit was a telephonic receiver. When the exploring coil was not in relation to a metallic substance, there was silence in the telephonic receiver; but, as the explorer approached or receded from the metallic mass, the balance was disturbed, producing a musical tone in the receiver. The sound is distinct six inches from the metal, if located in the human body. The new telephonic probe consists of a telephonic receiver and two wires, one terminating in a long, slender steel probe, and the other with a steel plate laid over the surface of the body in the neighbourhood of the metallic mass, as determined by the induction balance. The steel probe being now plunged into the body, as soon as it reaches the metal a distinct click is heard. The practical working of the instrument was shown by locating a bullet in the chest of a soldier wounded during the civil war. A piece of lead was also recognised in the centre of a piece of beef.

CONSULAR REPORT ON ELECTRIC LIGHTING IN VIENNA.—According to the abstracts of consular and diplomatic reports contained in the *Board of Trade Journal*, our Consul in Vienna is of opinion that nothing is wanting but the necessary capital to bring about the adoption of electric lighting there, for public as well as for private purposes, to a much greater extent than at present. The electric companies now transacting business in Vienna have, he says, so little capital at their command that they are compelled to insist upon immediate payment for all investments made on behalf of, and services rendered to, their customers. He is assured that any electric lighting company could at once enter upon a most lucrative and thriving trade in Vienna if its capital were sufficient to enable it to extend the necessary credit to its customers. The firms already established have, for want of capital, done but little business in the city; but in the provinces they have been more successful, as large industrial establishments have made use of the light. In these the price per hour for arc lights varies from 1·2d. to 3·6d., and for incandescent lamps from 0·12d. to 0·48d., according as gas, steam, or water is used as a motor. Our readers are aware that the Imperial Continental Gas Association has taken up the business, and has contracted for the lighting by electricity of the Burg Theatre, the two Imperial Royal theatres, and the Opera House. The Association's contract for the supply of gas in the city will not expire till Oct. 31st, 1899, up to which date they have the exclusive privilege of laying mains in the streets. They charge 5s. 5d. per 1,000 cubic feet for gas (16 candle) supplied to the private consumers; and 4s. per 1,000 cubic feet for that used for public purposes. The total consumption of gas for all purposes in the city has been estimated at from 1,758 to 2,110 million cubic feet per annum.

THE EMPLOYMENT OF SPIRAL SPRINGS FOR MEASURING INSTRUMENTS.—In a paper by Prof. W. Kohlrausch, in the *Electrotechnische Zeitschrift*, on the employment of spiral springs for measuring instruments and the accuracy of galvanometers constructed therewith, the causes which are likely to affect the constancy of spiral springs are mentioned in detail by the author, with an account of experiments bearing on each point, in order to afford some idea of the reliance that can be placed on the indications of instruments into the construction of which they enter. The effect of age, judging by observations on a brass spring extending over a period of seven years, may be completely neglected. Continuous and prolonged deformation produces a small amount of permanent set, so that the spring when released does not return to the original position, but does not actually alter the indications of the instrument if the readings are taken from the new zero thus found; steel is in this case less affected than German silver. Oft repeated, but intermittent deformation—as exhibited by a spring of 90 convolutions and 2½in. long, being stretched so as to change from a length of 3½in. to 9in. two hundred times per minute for four hundred minutes—introduced no appreciable alteration in its subsequent indications. An increase of temperature of 18 degrees Fahrenheit raised the indications of a Siemens torsion galvanometer about $\frac{1}{10}$ per cent., so that the reduction in the elasticity of the spring is apparently almost equal to the decrease in moment of the magnet, which would be, under these conditions, about 0·4 per cent. Further experiments on loaded springs confirmed this conclusion, and showed that steel was again to be preferred to German silver. By combining the results given above, the utmost limit of error introduced by the use of spiral springs cannot exceed 0·5 per cent. If, however, as is the case in the Siemens tension galvanometer, the

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current passes through the spiral spring, care must be taken that the heating from the passage of the current is not excessive. The author found an alteration of 1·4 per cent. in the indication of such an instrument after thirty minutes' continuous test, with a difference of potential of 100 volts between the terminals. If such instruments be calibrated at intervals to correct the decrease in the moment of the magnet, an accuracy within about 0·1 per cent. can be relied on. With the Siemens dynamometer for intense currents, the limit of error, owing to the friction at the mercury contacts, is about 1 per cent. Another form of instrument, the spring galvanometer of F. Kohlrausch, is also reliable within 1 per cent., and is perfectly aperiodic with frictionless damping. Owing, however, to the employment of an iron core, the readings of currents taken in ascending and descending order of magnitudes will vary to some considerable percentage from the effect of residual magnetism, which exists in even the best soft iron, if this error be not eliminated by mechanically bringing the core past the position it would take up under the action of the current, and then leaving it free to return to that position.

COLLIERY LIGHTING.—In a paper upon the "Safe Lighting of Collieries," read at Swinton by Mr. W. E. Teale, the author thus expresses his views on the application of electric lighting:—"Electricity for the purpose of lighting collieries will be largely used for surface and underground. Mr. Swan, Mr. Miles Settle, and others have given a great deal of attention to the subject. The lamp designed by Mr. Swan consisted of a secondary battery and a small incandescent lamp attached. But so far that system had not obtained any success on account of the weight, consumption, and the material the battery was composed of, the trouble of charging, and the cost of the lamp. The lamp might be used with good effect by generating electricity from a dynamo driven on the surface, and the electric fluid conducted down the mine by means of a wire, properly insulated, to the shaft bottom, and thence into certain portions of the mines where a fixed light is desirable, such as for lighting the bottom of pits, offices, stabling, and along main roads. Great care was needful to use wire thoroughly well insulated, and to fix it in such a position that it could not possibly cause short-circuiting, come in contact with wire, nails, or other metal, and so divert the current; also that the conducting wires might not be fractured, for if that were to occur, and explosive gas existed, the spark produced would inevitably cause an explosion. In order to prevent any possible ignition should the glass of an incandescent lamp be broken and expose momentarily the carbon filament in a state of incandescence, which, if placed in contact with explosive gas, would cause a disaster, Mr. Settle, the inventor of the highly-successful method of blasting by the water cartridge, proposed to surround the lamp with two globes containing water, air, or carbonic acid gas, and in the event of the outer globe being broken then a float would descend and break the contact. Mr. Settle also proposed to carry the wire right into the workings by means of pipes filled with water. At certain places there would be junctions at which couplings might be fixed in connection with a length of flexible tube containing the conducting wires of the lamp attached to the end, which might be hung up in a suitable position to work by. The difficulties in connection with the entire and sole use of electric light were:—1. The lamp did not disclose the atmosphere which a man might have to pass through, and there would therefore be the risk of men being suffocated by gas. 2. The colliery would require to be lighted as the streets, courts, and passages of a town were, throughout the whole length of the workings where men had occasion to go, either to inspect or to work, or they would have to carry a portable lamp to such places as were not lighted up. 3. The risk attending the fracture of the wire by the ordinary changes and movements of the wind, a fall of roof, or any accident which might place the pit in darkness, or by a spark of great intensity sufficient to ignite gas, should any exist at the points of fracture. 4. The great expense to light up a mine throughout, in some cases the scores of miles in roads and passages."

THE ELECTRIC LIGHTING OF AN ABERDEEN STEAMER.—We quote the following paragraph from the *Aberdeen Journal* as a good illustration of a passenger steamer's electric light equipment:—The steamship "St. Rognvald," belonging to the North of Scotland, Orkney, and Shetland Steam Navigation Company, has just been fitted up with a large installation of electric light. The plant, which has been supplied by Messrs. J. D. F. Andrews and Co., Glasgow, is similar to that which was introduced into the ss. "St. Clair," another of the companys steamer's, about a month ago, but is of much larger dimensions. The engine and dynamo machine are capable of lighting 120 lamps at 60 pounds pressure. The dynamo performs 500 revolutions per minute, and is of the compound self-regulating type. There are 108 lamps in all used for the lighting of the vessel, and these are divided into six circuits, which are controlled by a switch-board in the engine room. On the saloon circuit there are 38 lamps, these being again divided by three switches in the pantry, so that the steward can turn off or on the light either in the state rooms, deck cabins, or saloon. Each fitting is also provided with a switch, so that the lamp can be lighted by the passengers themselves. In the main saloon there are nine lamps fitted to handsome silver pendants, and when lighted produce a brilliant effect. From the fact also that it is a pure light without heat, the change should be thoroughly appreciated by passengers who have been accustomed to the dull, gloomy aspect below deck with the old system of oil lighting. The remaining lamps of this circuit light the state rooms, gentlemen's, ladies', and deck cabins, &c. Outside on the deck cabins there are placed three special watertight lamps for lighting the deck and gangways when passengers are being transferred to small boats or leaving the ship. The second cabin has 31 lamps, which light all places in the centre and fore parts of the vessel. In the fore cabin there are four lamps, two in the ladies' cabin, one in each of the officers' berths, captain's room, wheelhouse, &c. The masthead and side lamps are also supplied from this circuit. In each of these there are two lamps, and they are so fitted that in the event of any accident to the dynamo the oil lamps can be replaced at a moment's notice. A separate circuit is provided for each of the holds. The afterhold is lighted by ten lamps and the forehold with six. These are of special construction, being designed so that the cargo may be packed hard against them without injuring the lamp. There are also two deck lamps for the shipping and unloading of cargoes. These supply two deck clusters, placed over the hatchways, of 100 candle-power each. The engine room circuit has 13 lamps, which light the stoke-holes, tunnel-shaft, and various parts of the engine room. The stoke-hole lamps are made portable, so that they can be taken to examine any part of the boilers. The whole of the installation has been admirably fitted up under the personal supervision of Mr. W. C. Martin, the representative of Messrs. Andrew and Co. The same firm have also in hand a large number of steamers into which the electric light is to be introduced, including the "St. Sunniva," also belonging to the Orkney and Shetland Company, the "Earnholm," and several vessels yet in the shipbuilder's hands both on the Tyne and on the Clyde.

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 413.)

Turning now to the practical applications of electro-magnetic science to dynamo machines, we will first make a general examination of the Gramme and Siemens dynamos, in which we shall trace the more important features, and afterwards, taking each part in detail, we shall deduce some rules to guide us in the general proportions; we shall then apply the formulæ to a particular example in each type, and conclude this part of our subject by endeavouring to draw some comparison.

The Gramme ring consists of an annular iron core wrapped with copper wire, the latter being wound on in one direction and forming a closed circuit in itself around the ring.

Connection is made from a similar point in each coil or section of coils to an insulated segment of a circular commutator which furnishes a means of making contact with various points on the armature circuit. A reference to Fig. 3 will bring the conditions of both the electrical and magnetic circuits clearly

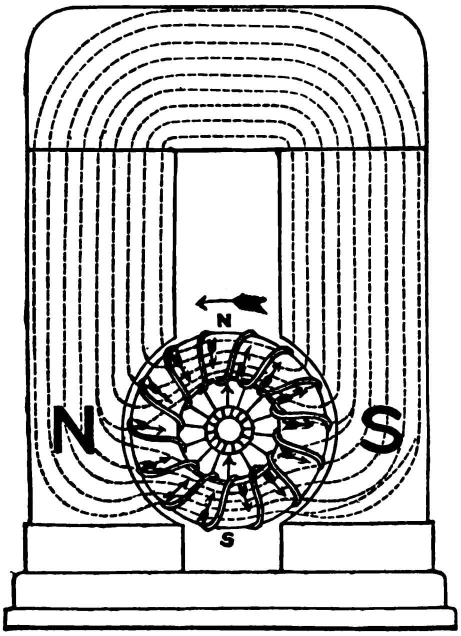

FIG. 3.

before the mind. The magnetic circuit is closed, with the exception of the gap between the pole pieces and the armature core, the path of the lines being indicated by the dotted lines. It is evident that, apart from the copper coils, the surface of the iron core itself will be continually cutting through the lines of force and generating wasteful currents, which will eddy around it chiefly in the direction of the winding. These eddy or "Foucault" currents are avoided by dividing the iron core into laminæ electrically insulated from each other at right angles to the piercing of the lines.

In cases where the top surface only of the core is exposed to the aforesaid piercing it is sufficient to laminate in one direction perpendicular to the spindle, which is conveniently done by building up the core with thin iron washers, but where the polar surfaces are extended to the side faces of the core, lamination in two directions is necessary; the core should then be constructed of insulated iron wire.

Fixing our attention on any particular coil we see that, whilst moving across the horizontal plane between the poles, the rate of cutting lines is a maximum; on the other hand, whilst moving across a vertical plane between the neutral points in the field no lines are cut; and further, we see that the lines are cut in an opposite sense whilst the coil sweeps through the field on one side of the neutral line to that when it traverses the other side. The direction of the E.M.F. changes, therefore, at the neutral points, the result being that the current flows from one neutral point towards the other in both sides of the ring. These opposing electromotive forces would naturally destroy each other were it not for a third conductor (consisting of the field-magnet, coils, and external circuit) which is added to the system. Fig. 4 shows this condition in diagram. The ends of this third circuit are brought into rubbing contact with the proper points on the commutator by means of the brushes B B, which are so arranged that the diameter of contact may be adjusted to coincide with the true neutral diameter of the field.

The E.M.F. generated in any wire in absolute units is, as we have seen, expressed by the formula $E = M b v$, where b is the length of the wire, the field M being uniform. $M b v$, therefore, merely represents the number of lines cut per second. So that in order to obtain an E.M.F. equal to E it is neither necessary that the wire should be of any particular length, nor the field of uniform density, providing that, as before, the same number $M b v$ of lines are cut per second. The E.M.F. due to a single coil on the armature will thus be measured by the total number of lines cut by it per second, irrespective of its length. The lines cut in the half revolution from one neutral point to the other must evidently be that number which pass through the core of the armature; supposing a to represent the cross section of iron in the core, and M the number of lines per square centimetre, then the total number of lines cut in one complete revolution will be $4 M a$.*

The electromotive forces in one half of the coils are summed, the two halves of the winding being connected in parallel through the brush contacts; if N be the total number of coils

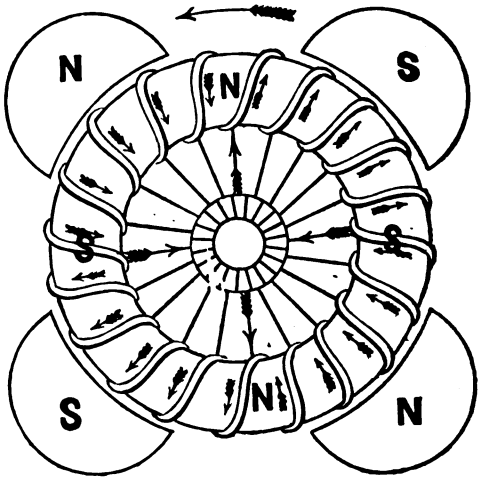

FIG. 4.

on the armature, and n the number of revolutions per second, the total E.M.F. generated in the armature will be

$$E = 4 M a \frac{N}{2} . n.$$

To express this in volts we must divide by 10^8, as there are 10^8 absolute units of E.M.F. to one volt, thus

$$E = 2 M a N n 10^{-8} \text{ volts.}$$

It is more convenient in practical engineering to work in minutes and inches than in seconds and centimetres, and as we have already converted absolute units into volts, in order to enable us to handle the figures more readily, there seems no reason why these other conversions should not be effected with the same object. In the equation M stands for the density of absolute lines per unit of area, a. Any alteration in this latter unit will therefore leave the product $M a$ unchanged; the substitution of minutes for seconds in regard to n, however, will be tantamount to increasing the value of each line sixty-fold. In a paper by Kapp, read before the Institution of Civil Engineers in November, 1885, the numeric 10^{-8} is also changed to 10^{-6}, thus making the arbitrary line equal to 6,000 absolute lines. With this explanation the author will adopt the arbitrary measure here indicated for the sake of its greater convenience in practical application. The formula for the E.M.F. in the armature coils will now read

$$E = 2 M . a . N . n . 10^{-6}.$$

* It will be borne in mind that the lines divide on leaving the pole, one half going in each direction through the core, thus making $2 M a$ lines, which are cut twice in a complete revolution of the coil.

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In the Siemens or drum armature the distribution of magnetic lines is precisely the same as in the ring, the only difference in the two machines being in the winding of the coils, which in the drum are wrapped over the outside only, instead of being brought through the interior. Owing to the coils being wound across a diameter of the drum, the E.M.F generated in the two sides of the coil will be in opposite directions in space, this being actually in one direction in the coil itself. As before, the direction of E.M.F. changes on passing the neutral points in the field.

From the mode of winding in the two machines, it is evident that in the drum an equal number of lines are cut as in the ring, but with a much shorter length of wire. In the most usual form of drum winding, however, there is this serious practical objection, viz., that each successive coil has to cross over the preceding one at the ends of the drum, and considerable difficulty is presented in securing adequate insulation at these points; moreover, should any injury be sustained, it is more likely than not to be found in the first coil, and can then only be repaired by a complete rewinding of the armature.

By a most ingenious system lately introduced by Messrs. Siemens the chances of such injury have been so far removed that their drum-winding may now be considered as safe in this respect as any other system.

On account of the absence of interior wire each complete coil is twice as active as before, and in the equation for the total E.M.F. N will now stand for one-half the whole number of coils, but will still represent the total number of wires counted all round the exterior of the armature. So far we have assumed the formula for those cases where the field proceeds from two poles only. This restriction is not, however, necessary. Take the case, for instance, of a machine with four poles of alternate sign, and with four contacts on the commutator, the number of coils in series will now be $\frac{N}{4}$, instead of $\frac{N}{2}$; but, as each coil will cut the field four times instead of twice, the E.M.F. will be expressed by the same formula as before.

In multipolar machines the alternate contacts are connected together either outside the commutator or within it. In the latter case the extra contact brushes are superfluous, and may accordingly be dispensed with. Fig. 5 represents the direction of current in the armature of a four-pole machine.

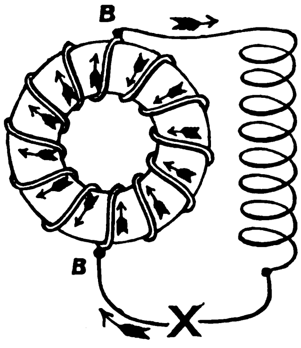

FIG. 5.

In setting about the design of a particular machine, we are at once confronted with the problem of how to arrange matters so as to fit all the requirements, and yet to give no unnecessary or undue prominence to any one portion of the design. This can only be managed in a general and satisfactory manner by the aid of a little mathematical treatment.

We must, of course, be sure that the proportions, which may be very nicely calculated, are not based on some impossible achievement in the way of, say, speed or magnetic induction. With regard to the latter quantity, we know that the permeability of the best wrought iron is limited, and we must know this limit with sufficient accuracy, and keep our assumed magnetic density within it.

In like manner the density of current in the coils of the armature is limited by the cooling surface presented by the wires. For all practical purposes this may be taken as directly proportional to the surface of the core, which is easier to deal with in the calculations.

We are of course assuming that the heating due to Foucault currents is negligible, which, in a well-designed machine, should be the case. It is not possible to make a hard and fast rule as to the heat generated per unit of cooling surface, because so much depends on the speed and ventilating properties of the machine; but, according to Mr. Kapp, we may take as a fair average one watt per square inch when travelling at a peripheral velocity of 3,000ft. per minute. The cooling properties of different designs, however, vary so much that we shall retain the coefficient in our formulæ, which will then be of a perfectly general character.

What we require to know in designing a machine of a particular type to do a certain work is—(1) the linear dimensions of the core (upon which the copper depth generally depends), together with the gauge and plan of winding; (2) the dimensions and winding of the field-magnets necessary to fulfil the conditions of magnetic induction assumed in the design of the armature. These two portions of the machine require separate treatment, and we will proceed first to deal with the armature.

(To be continued.)

THE TRANSMISSION OF ENERGY.—AN EXTENSIVE SCHEME.

We are enabled this week to lay before our readers some account of a proposed installation for the electrical transmission of energy upon a very large scale. The fact that the electrical details of the scheme have not as yet been decided upon has induced us to take some trouble to learn the actual facts of the case, in the hope that the information may be of use to some of our readers. It must be confessed that the work is of a character of which comparatively little experience has hitherto been gained, but if the economic conditions are not unfavourable, there is no reason to anticipate any serious difficulty of a technical nature. An impression appears, indeed, to exist in the public mind—an impression which is certainly not unnatural, and which may or may not be correct—that only one living electrical engineer (of French nationality) is competent to undertake an installation of this order. An opportunity now arises either for correcting or confirming this impression, and we may add that unless a move is speedily made elsewhere, the latter result will in all probability follow.

The scheme in question contemplates the transmission of some 3,000 horse-power over a line 35 miles in length, from Chulilla to Valencia. The city of Valencia has a population at the present time of about 150,000, and is the seat of a considerable manufacturing industry. Power is to be obtained from the River Turia, and it is estimated that the force available for conversion will slightly exceed 3,000 horse-power in summer, and in winter will amount to more than double this figure. The reports which we have now before us are, however, based upon a mean available force of 4,200 horse-power.

The promoters of the scheme have already gone so far as to have obtained the necessary legal powers. They also appear to have given careful consideration to the whole of the details of the mechanical and hydraulic engineering; but at this point, for the present, they stop short, and with respect to the electrical arrangements they are open to receive plans and suggestions. We are in possession of tolerably complete information with regard to the matters already decided upon by the hydraulic engineers, but as we have already intimated, it will be sufficient for our immediate purpose if we put before our readers enough information to enable an opinion to be formed upon the requirements of the electrical installation.

The adjoining map shows the topographical features of the district in which the source of power is found. It will be seen that here the River Turia describes roughly a semi-circular arc. Along a chord of this arc, measuring 2,238 metres, or 1·37 mile in length, it is proposed to cut a canal, at an almost horizontal level, thus obtaining at the outlet a fall of 33 metres, or 108ft., to the bed of the river. The line of the canal is, however, intersected by a range of rugged hills, under which it will be necessary to tunnel for a distance of rather more than one mile, as shown by a dotted line upon the

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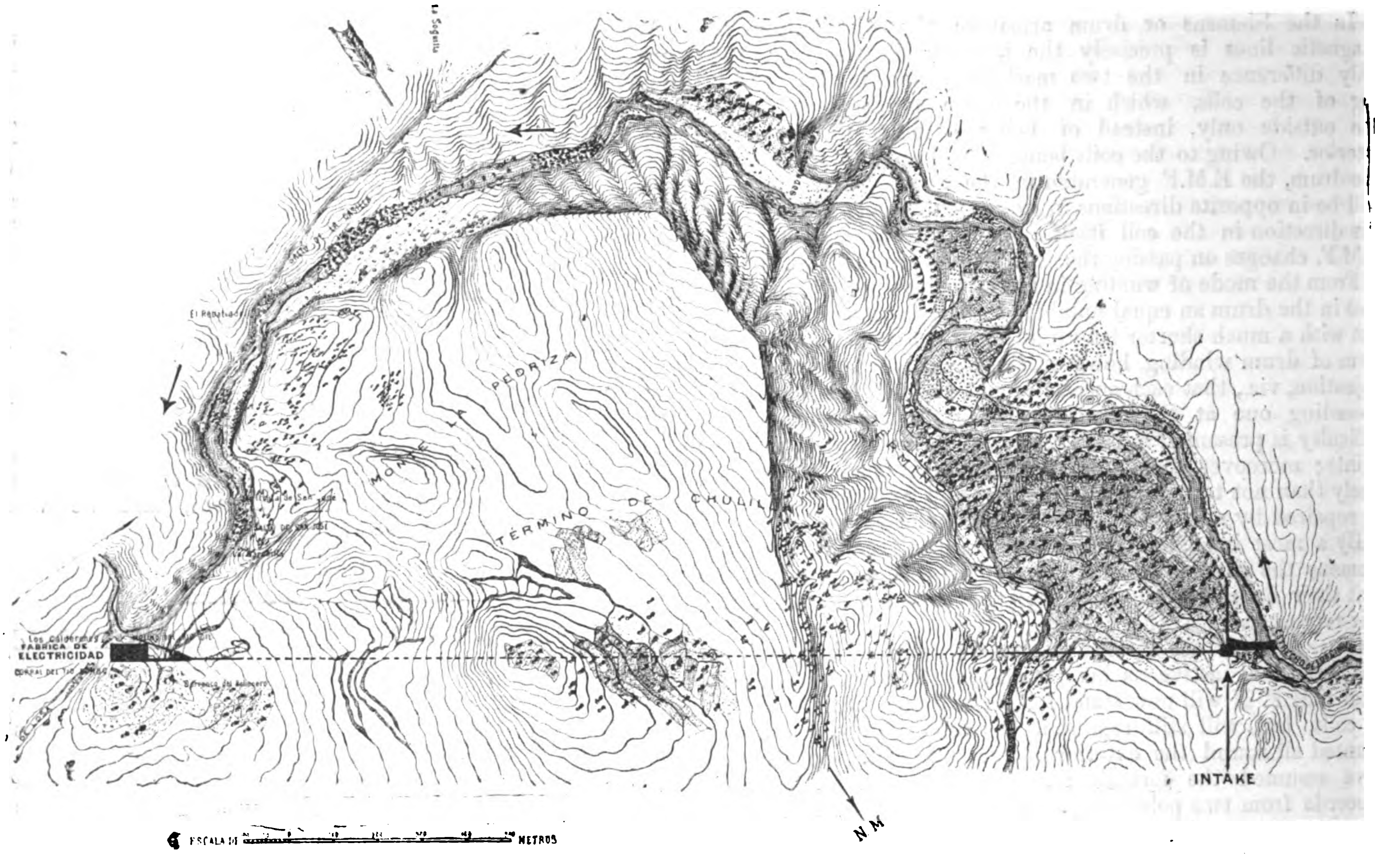

THE TRANSMISSION OF ENERGY IN SPAIN.—PLAN OF THE RIVER TURIA.

map. The intake will be effected at a point where the river issues from a deep and narrow ravine (the Pass of Cingdos), and it is easy to see that this configuration offers peculiar advantages for impounding the flow and constructing the necessary dam and sluices. At the farther end of the canal we are informed that the ground is favourable for the construction of a reservoir upon the higher level, and for the erection of the machine house upon the river bank.

The mean annual volume of water to be dealt with is stated, after numerous experiments, to amount to 10 cubic metres, or 353 cubic feet per second, which under a head of 108ft. will be found to account for the 4,200 horse-power (theoretical) already mentioned. It is proposed to utilise this force by means of Jonval turbines, for which an efficiency of 70 per cent. is assumed, thus yielding a brake horse-power of 2,940, or, say, 3,000.

We have therefore to consider the problem of the conversion of 3,000 horse-power, its transmission to a distance of 35 miles (along or near to a public highway for the most part), and its reconversion into available form at the point of distribution. As we have already intimated, this portion of the scheme has not yet been definitely formulated, but in order to obtain an approximate idea of the probable outcome, especially with regard to the important question of the economic value of the scheme, we may follow the report before us in assuming that 1,460 horse-power, or a little less than 50 per cent., may be obtained in a mechanical form at Valencia.

The report itself is largely taken up with a recapitulation of M. Deprez's experiments between Paris and Criel, which chanced to be about the same distance apart. But as the minimum power transmitted by Deprez did not exceed 100 horse-power, it need hardly be said that the assumption of the same efficiencies throughout is a little gratuitous. However, as it is not our present intention to discuss the electrical problems involved, we shall assume that the above figure of 1,460 horse-power mechanical is available at the terminal station

The question to be considered next in order is the cost of obtaining this energy by transmission as compared with its immediate development from steam power. On this point we can, of course, merely quote the figures supplied to us, without making any suggestion as to the value of the coefficient of reduction which should properly be applied. The items set out in the following tables are not in all cases very clearly defined, but we quote as literally as possible. No statement is made as to the means by which the cost of the electrical equipment has been arrived at:—

Table I.—*Cost of Production of Electric Energy.*

Interest, Redemption, and Repairs—	
5 per cent. interest upon £133,112, the amount of the general estimate of works, machinery, and electrical material	£6,655
1 per cent. upon £21,325,* amount of the buildings and other constructions for its redemption in 100 years....................	213
5 per cent. on £7,067, cost of the turbines, sluices, and other hydraulic machinery, for redemption in 20 years	354
5 per cent. on £33,614, cost of electrical material, for redemption in 20 years..	1,681
2 per cent. on £38,438, amount of electric conductors, posts, and other accessories, for redemption in 50 years	769
½ per cent. on £53,992, allowance for maintenance upon all the works included in the general estimate	270
1 per cent. on £7,067, allowance for maintenance of the hydraulic machinery..	70
2 per cent. on £72,053, allowance for maintenance of all the electric material	1,441
	£11,453

* In this amount articles 1 and 2 of the general estimate for works are not included, which, with the 5 per cent. for unforeseen expenses, amounts to £32,668.

If we correctly understand this table the estimate for capital expenditure amounts only to £187,100. The total additional annual charge for administration, works, rent, and miscellaneous outlay (of which voluminous details are supplied) is estimated at £6,523. So that the total annual outlay amounts upon this basis to just £18,000. (We do not care to follow our Spanish friends into estimates of half-a-crown in matters of this sort.) We have no information as to the cost of coal in Valencia, but it may be as well to state that from a rough calculation it would appear that 1,500 horse-power could be obtained at about the same annual cost directly from steam power if the price of coal exceeded thirty shillings per ton.

The other side of the account is set out as follows:—First, it is assumed that during the hours of daylight the whole of the 1,460 horse-power can be retailed as motive power, and that the mean annual daily value of 1 horse-power (at the generating station) supplied under these conditions amounts to 1s. 8d. The revenue from this source is therefore estimated

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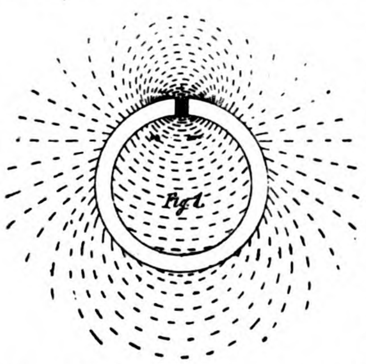
at £42,600 per annum. Then in addition to this, and for reasons not set forth in detail, it is assumed that a revenue of £28,600 per annum is available from the electric lighting department. The total revenue (anticipated) being thus £71,200 and the expenditure (estimated) £18,000, the annual return is thus shown (on paper) to amount to £53,200, or about 30 per cent. on the capital outlay.

Just before going to press we have received a telegram from Spain, in answer to our letter of inquiry, that the promoters of the scheme are quite open to receive suggestions, and to transact their electrical work with an English firm.

THE EVOLUTION OF AN IRONCLAD DYNAMO.

At a recent meeting of the Electric Club of New York a paper of singular interest was read by Mr. Rudolf Eickmeyer. Mr. Eickmeyer modestly described himself as "an amateur not so very familiar with the technical phraseology of electricians," and it must be conceded that the paper does to some extent bear evidence of this fact (as, for instance, in the use of the term current where, strictly speaking, E.M.F. is intended). But this circumstance does not in any sense detract from—in fact, it considerably enhances—the interest of the communication, seeing that Mr. Eickmeyer, by a well-thought-out and consecutive series of experiments upon the magnetic circuit, has arrived at views which are for the most part practically identical with the latest developments of theory and practice in our own country. It is additionally interesting to note that Mr. Eickmeyer eventually arrives at a type of machine which carries out to its fullest extent the hint recently given by Prof. Forbes, to magnetise the armature rather than the field. The following is Mr. Eickmeyer's paper :—

When a soft iron ring is wound with an insulated copper wire, and the copper wire is put in circuit with a battery, a magnetic current is produced which gives no external evidence of its existence. There are no poles, and no lines of force can be seen when iron filings are sprinkled on a card-board above it ; yet, if a secondary wire is put over the primary and the primary is broken, an induced current is produced, the same as if a straight magnetic bar of iron had been used. If, however, the iron ring is cut open at any point, the poles and lines of force appear at once. Fig. 1 represents the appearance of the lines of force when such a ring is cut open at one point and some of the iron removed. Two centres appear, around which the lines of force bend from side to side. At the point where the ring is cut the fillings pile up and the curves connecting the two ends are sharp and well defined. Less distinct curves appear at the point directly opposite the opening where the lines of force run from side to side and around that point. The removal of a portion of the ring has developed two poles and a magnetic field of force. The lines of force are most dense between the two faces and the portion of the iron near the ends, and become less and less well defined as they start nearer to what is called the "neutral point" in the magnet.

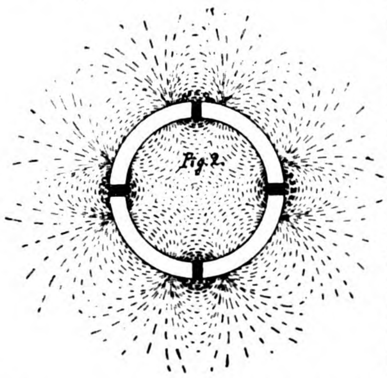


The field of force thus produced can be used in an electric generator or electric motor. And all those lines of force which pass through the armature, and no doubt represent the largest portion of the magnetic current, are cut by the armature when rotated. That portion of the magnetic current is wasted, however, which is indicated by those lines which complete their circuit outside of the armature, or, as it is termed, scattered. The simplest form of an electric generator or motor is the copper disc used by Faraday in his experiments. The disc when rotated between the two ends of the iron ring produces a current which flows from its axis to the periphery, thus furnishing a simple means of testing the value of the field of force. The magnetic circuit in this case is formed by the magnet and armature, and the magnetic current in the machine passes through the iron ring and the armature.

Now, if the iron be cut at any other point the magnetic circuit would again be broken and a new field of force would be the result. The magnetic current would again flow from end to end at the new opening, continue its passage through the iron to the next opening, and so on to complete its circuit.

In Fig. 2 is shown a ring exactly like Fig. 1, but cut at four points. The figure shows that the filings now pile up at four points above the four cuts, forming four centres around which the lines of force bend. Midway between the segments are four more centres of other curves, which complete their circuit from the end of each segment to the other end of the same segment, and do not pass from one segment to another. Four fields of force are here produced, each of which could be utilised like the original field, and the density of any two should be equal.

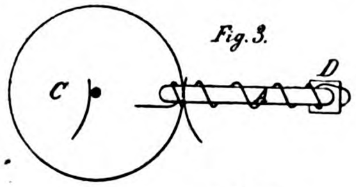
Now, the question is, what is the relative value of these four fields of force as compared with the original one, when but one opening was made in the metallic circle ?

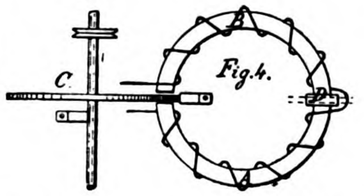


In order to determine approximately the relative values of one or two fields of force in the same magnetic circuit, the machine shown in Figs. 3 and 4 was constructed. Two semi-circular electro-magnets A and B were so arranged upon a support that a disc, C, could be freely rotated between their two faces. In the first experiment a copper disc with suitable brushes was rotated between the faces of the magnet, while the opening between the magnet at the other end was closed with a piece of soft iron, D, nicely fitted and somewhat larger than the faces of the magnet ends. The magnetic circuit was thus closed, except at the point where the disc was inserted and the lines of force, as seen when examined by means of iron filings, showed by a slight accumulation on the two sides of the piece D that the magnet was not continuous. Yet, on the whole, the figure produced had the characteristics of Fig. 1.

The rotation of the disc when the helix was excited produced a deflection of 19 deg. in an ordinary tangent galvanometer with a fine coil. D was then removed, while all other conditions remained as before. The galvanometer showed a deflection of 14 deg. The loss of energy thus indicated was due to a second opening in the magnetic circuit.

In this experiment a copper disc had been used, In order to reduce the resistance of the magnetic current an iron disc of the same size as the copper one was now put in the machine. When the piece of iron D, which connected the magnets at the second opening, was put in place, and the disc rotated, the galvanometer now showed a deflection of 33 deg. D was now taken out and another of the exact thickness of the iron disc was put in the second opening, and insulated from the faces by pasteboard equal in thickness to the space between the disc and the magnet faces. In this condition the galvanometer recorded a deflection of 24 deg., and when all the iron was removed 19 deg. The use of the iron disc had increased the deflections of the galvanometer from 19 deg. to 33 deg. when the magnetic circuit was completed by the block of iron D. It had increased the deflections from 14 deg. to 19 deg. when the block of iron was removed ; and when a piece of iron of the thickness of the iron disc was inserted in the second opening, and insulated with pasteboard, the current produced by the rotation of the iron disc deflected the galvanometer 24 deg. or 25 deg.—more than that produced by the copper disc when the magnetic circuit was completed by the block of iron D. The iron disc had demonstrated that by its use each of the two fields of force could furnish a current equal at least to that produced by the copper disc. The action of the iron disc in the experiment was no doubt due to the fact that its introduction in the field of force had reduced the resistance to the magnetic current at least one half. It is clear that the four fields of force in the ring, Fig. 2, could be made equal to the field in Fig. 1, provided the resistance to the magnetic current was sufficiently reduced.





(To be continued.)

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THE ELECTRICIAN.

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CONTENTS.

Notes ... 429
The Practice of Dynamo Design. By Guy C. Fricker. (Continued.) Illustrated ... 434
The Transmission of Energy. An Extensive Scheme. Illustrated ... 435
The Evolution of an Ironclad Dynamo. Illustrated ... 437
TECHNICAL EDUCATION AGAIN ... 438
Correspondence ... 439
Applications of Electricity to Mining Operations. By F. J. Rowan, C.E. (Continued.) ... 439
Taussig's Automatic Fire and Burglar Alarm. Illustrated ... 441
Physical Society ... 441
Society of Telegraph-Engineers ... 442
Regulations for Electric Lighting in the Paris Theatres ... 446
Electric Lighting Act (1882) Amendment Bill ... 447
Legal Intelligence ... 449
Companies' Meetings—
German Union Telegraph and Trust Company ... 449
Montevidean and Brazilian Telegraph Company ... 449
Direct Spanish Telegraph Co. ... 449
Electrical Power Storage Co. ... 450
City Notes, &c. ... 450
Companies' Share List ... 450

TECHNICAL EDUCATION AGAIN.

Lord HARTINGTON'S very sensible remarks on technical education at the Polytechnic last week have been quickly followed up by a deputation to the Education Department, putting his views into a more or less—perhaps rather less than more—practical shape for the consideration of the State. The science, technical, and art students whom Lord HARTINGTON addressed, and who are described as Polytechnic Christian young men, were more fortunate than their fellow students elsewhere usually are on such occasions. Some confusion is apparent in his Lordship's address as to the meaning of the terms scientific and technical, a confusion which may be excused in a busy Statesman who is occupied more with the substantial political aspects of the question than with its phraseology. But, on the whole, his words were appreciative without being over laudatory, and encouraging without being extravagantly sanguine. His expressions of surprise that Trades Unions, which have done so much to improve the wages of the working classes, had done so little for their technical instruction were entirely wholesome and well timed. Whether the employers have been similarly neglectful may perhaps be doubted, for if the money which has already been spent on technical schools and institutes has not mainly come out of the pockets of employers we do not know who else has provided it. He hoped that the time would not be far distant when our Town Councils, Local Governing Authorities, or School Boards would establish industrial and technical schools in every considerable centre supported by local means and aided by national funds. We entirely share these hopes; but in order that they may be realised it will be necessary to drive home the remarks which followed, namely, that the lower middle classes require to be convinced "that the position of a skilful and educated mechanic is far better than that of a clerk in a mercantile firm."

By educated we presume that technical education was meant; and, if we are right in this, then the remarks apply to a grade below the lower middle class—that is to say, to the classes from which artisans, as a body, are drawn. And here we come across a fact which has grown more and more plain ever since the effects of the Education Act began to tell upon this class of society, and which was no doubt present in Lord HARTINGTON'S mind when he made use of the words just quoted. This fact is, that the tendency of the Act has been to inspire the classes in question with the ambition of becoming clerks. What is the use of education, they argue, unless the children to whom it is given rise to the level of the classes who formerly enjoyed the monopoly of educational advantages? A plethora of clerkly candidates fresh from the Board Schools, and indisposed for hard work, is one of the conspicuous consequences; and when the dearth of situations in this field becomes manifest, the further result is an accession to the labouring classes of discontented young men who aspired to something they deemed higher, and who resent every suggestion that they should improve themselves in their natural position by a further dose of "education." Of course there are many striking exceptions to this rule; but the rule itself has been constantly proved by the returns of such institutions as the Polytechnic, where the artisan element is very small compared with the class just above it. As regards the adult working men, their aspirations, as revealed in the action of Trade Societies in this country, and still more notably in the United States—where primary education is better than it is here—extend no higher than to increase their own wages, not by title of higher qualifications, but by more systematic exactions from the profits of their employers. For secondary education among this class the demand is practically *nil*. It is not surprising, on the other hand, that employers feel no very great enthusiasm for technical education, the cost of which constitutes a further charge on their profits.

Now, having these facts in mind, it does surprise us to see the names of the deputation which waited upon Lord CRANBROOK and Sir WILLIAM HART DYKE, at the Education Department last Monday, for the purpose of promoting secondary, or technical education. That deputation was largely composed of the very men once foremost in promoting primary compulsory education, and who have done all they could to extend the scope of this education in every conceivable direction save one. The one exception is that to which they now profess themselves to be devoted, namely, the technical and industrial education of the working classes. Even now they are unwilling to confess that the education which they desire to inaugurate, and which they rightly urge is so indispensable to the national welfare, is in reality the groundwork of all education worthy the name, and not an adjunct or an afterthought to be added on by extra pressure, extra persuasion, aud extra taxation. The Education Department is asked to empower School Boards and Local Authorities to found or to give aid to schools fitted to promote technical and commercial education. What, we should like to ask, in the name of common sense were the existing schools founded for, and why are they maintained at a vast expense if not to fit the scholars for the avocations of their future life? Casting our eyes down the list of names which formed the deputation, we suspect that their answer would be—if, indeed, they answered truly—"Oh, no, the object of the existing rate-supported schools was to teach everybody primarily to read the daily newspapers, in order that they should not attend to their own business, but take a livelier interest in politics, and vote solid for the men who granted them this inestimable boon. An industrial education, it is now apparent, would be more useful from the national point of view, but we must forego nothing of the original programme, which went a long way beyond the three R's, and is tending further and further every year in the direction of a still higher educational standard. What we require now is the foundation of separate technical schools, which the

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State should pay for, chiefly because the ratepayers will not stand any more direct demands on their pockets."

This, we conceive, is the true representation of the case for technical education as represented by the deputation, at the head of which were Mr. MUNDELLA and Dr. LYON PLAYFAIR. Lord CRANBROOK, we are rejoiced to notice, reminded them that every School Board and Local Authority already possessed powers to add industrial or technical instruction to the present course of education. He might have gone further, and told them that they could considerably reduce the ambitious projects formed in many of these schools, substituting education suitable for the locality in their stead. Technical, or what leads to the same thing, industrial training is what we ought rather to begin with, not end with. The ideas which are prevalent on this important subject require to be entirely reconsidered and recast. Industrial competency will not be achieved so long as we relegate its attainment to a secondary place in point of time. In some nations—largely in Germany—the industrial training goes side by side with the ordinary schooling; every boy is taught some handicraft, and every girl some domestic art; but we know of no nation that attempts to make a craftsman out of material upon which exclusive pains have been taken to give it the education of a gentleman. Only in England—unless it may be also true of the Democratic States of America—do we begin on the supposition that every boy is equal in point of capacity, and equal also in social outlook, leaving it for chance alone to determine whether scholarship or handicraftship shall be his goal. Chance, in this relation, determines that he arrive at neither; and thus it is that the expanded aims of the national education system, while it has added nothing to the scholarship of the nation, has perceptibly lowered its technical and industrial efficiency. If we want technical superiority we must strive for it in a rational way; and, for our part, we should be glad if the Education Department would discourage some of the purposeless extravagances of Board School managers by directly encouraging an education, industrial and technical, more in keeping with the real wants of the people, and the pressing needs of this manufacturing and commercial nation.

CORRESPONDENCE.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to Mr. Herbert W. Butler, "per lb. of Pb" signifies "per lb. of *lead* in the battery," whether the element be in the metallic form or in combination. When accuracy is required, the weight of lead is calculated by multiplying litharge by ·928, red lead by ·906, or peroxide of lead by ·866. The capacity of 16 ampere-hours was *per lb.* of negative (lithanode) plate. Excepting when there is insufficient contact with the plate for a given rate of discharge the composition of the plate after discharge would appear to be remarkably uniform; but this point and many others have been insufficiently experimented upon.

The "bad conducting power" of the plates would not affect capacity in the abstract, but in relation to rate of discharge. If Mr. Butler can bring the active material into "more intimate contact with a good conductor" inexpensively, and without constituting an active local couple or greatly increasing the weight of the element, I should be glad to hear from him. I am not quite certain, however, whether he understands that my work for years has been to dispense with any contact with an oxidisable conductor. I should also be glad of a specimen of the "active material" possessing a useful capacity of 40 or 50 ampere-hours, and so no doubt would be many others.

I cannot agree with Mr. Butler that the "permanent" diminution of E.M.F. in a reversible lead battery is due to the exhaustion of the acid in contact with the active material.

In regard to the life of the lithanode plates, I may mention that I have had some small plates of my own manufacture in frequent use for about two years, and that they have not in any way deteriorated, but, on the contrary, have improved. In a report which I have seen, from Mr. H. Lea, of 38, Bennett's-hill, Birmingham, that gentleman observes: "At the end of the 22nd charge the anodes were to all appearance just as sound and good as when first received. No scaling, or softening, or buckling were discoverable."

The Union Electrical Power and Light Company, whose temporary offices are at 127, Cannon-street, E.C., have not considered it necessary to confer with me, or to notify to me their views and intentions; so that I am unable to inform Mr. Butler whether there is any likelihood of his obtaining "Union" cells from them. On inquiry, however, I am informed by the secretary of the company that they are manufacturing plates, and Mr. Butler would probably obtain information by applying to them directly.—Yours, &c.,

DESMOND G. FITZGERALD.

6, Akerman-road, Brixton.

APPLICATIONS OF ELECTRICITY TO MINING OPERATIONS.

BY F. J. ROWAN, C.E.

(Continued from page 424.)

IV. VENTILATION.

At the *Mines of Blanzy* a stone drift was ventilated by a fan driven by an electro-motor. The shaft was 550 yards deep, and the drift 430 yards long, or 980 yards in all, and the air had to be carried this distance in pipes 11¾in. diameter.

The drift was first aired by means of a waterfall, but this was proved to be insufficient, as the temperature at the fan was 95°. A fan was then put into the drift 150 yards in and driven by electricity, wires being led down the shaft from the dynamo for that purpose.

The fan was 2ft. 6in. diameter, by 11¾in. broad, and at 730 revolutions per minute delivered 13·42 cubic feet of air per minute at the face. The temperature was thus reduced to 89°.

When the Gramme dynamo at the bank was run at 1,200 revolutions, the one in the mine used as a motor ran at 700 to 800, giving about 60 per cent. efficiency.

COMPARATIVE OF COST VENTILATING BY ELECTRICITY AND COMPRESSED AIR.

Electricity.

Portable engine, 10 H.-P.		
2 Gramme machines	£120	0
Conducting cable (copper)	21	0
Return cable (iron)	3	15.64
Fixings for cable in shaft	0	14.40
Frames to carry motor and fan	2	1.88
Frames to carry dynamo and engine	7	4.00
Erecting	4	19.68
Shaft for engine	10	0.00
	£169	15.60

Compressed Air.

Portable engine, 10 H.-P.		
Compressor (Sauter and Lemonnier)	£349	6.0
Pipes	188	16.0
Elbow, &c.	0	14.4
Fixings in Shaft	3	0.0
Bolts and India Rubber Rings	3	0.0
Erecting	12	0.0
Masonry and Concrete	6	0.0
Shaft for Engine and Compressor	20	0.0
Sundries	8	0.0
	£590	16.4

Zankerode Pit.—For the separate ventilation of a lateral drift of the Zankerode mine a 40-inch Schiele fan is used, driven by a Siemens dynamo actuated by a Dolgorouki steam

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engine. The cost per 1,000 cubic metres is 0·27d., which is said to be cheaper than compressed air machinery where special compressing plant for a small fan has to be put down.

Trafalgar Collieries.—From the note supplied by Mr. Frank Brain, it appears that a 6ft. fan is being driven in the workings of this colliery at a distance of 1,500 yards from the generator in the engine house at the surface.

V. APPLICATIONS OF ELECTRICITY ILLUSTRATING GENERALLY THE TRANSMISSION OF POWER.

(*a*) *Marcel Deprez's Experiments* on transmission of power. Between Paris and Creil the length of the line between the two stations is 56 kilometres (about 35 miles); and the return circuit being by wire, not earth, the total length of wire traversed by the electric current was 112 kilometres of a copper cable, equal to a single copper wire of 5 millimetres in diameter.

All the conditions of current, resistance, speed, and horse-power were carefully measured and recorded, with the result that the generating dynamo running at 170 revolutions per minute developed an electromotive force of about 5,700 volts, with 7 amperes of current, and a brake horse-power of 61. The receiving machine or motor, running at 277 revolutions, received over 4,400 volts, and developed a brake horse-power of 40. There was no appreciable heating of the motor. The efficiency of the apparatus or the percentage of yield, both electrical and mechanical (or commecial), are, for two trials, as follows:—

Electrical yield	77 per cent. ...	78 per cent.
Mechanical yield ...	47·7 „ ...	53·4 „

These are percentages of the electric force generated, but do not show the relation of the power received to that which was exerted in driving the generating dynamo.

This is, however, given in an exhaustive report to the French Academy of Sciences by M. Maurice Levy, as reporter of a commission appointed to verify Mr. Marcel Deprez's results.

M. Levy reports that the power consumed at Creil in driving the dynamo varied from 67 to 116 horse-power, as the speed of the generator was varied from 168 to 218 revolutions per minute, and the electromotive force from 4,887 to 6,290 volts.

The power recovered at Paris varied from 27 to 52 horse-power; the industrial yield having thus varied from about 41 to 45 per cent. of the original power employed. The percentage recovered increased with the increase of horse-power transmitted, the highest percentage (viz. 45) having been realised when 116 gross horse-power were used, and 52 recovered at Paris. M. Levy remarks that "The fact that we can thus practically transmit 116 horse-power to a distance of 56 kilometres, and derive an industrial yield of 45 per cent., accurately measured, not exceeding a velocity of 218 rotations of the generator, and this continuously, without straining the machines, is an extremely remarkable result, which could not easily be expected, and which must be emphatically pointed out."

The analysis of results of M. Levy shows that the machine employed by M. Deprez produced electrical effects equivalent to those which would have required 200 Gramme machines using five times the power consumed in the Deprez generator. The loss of power being the difference between 116 and 52 or 64 horse-power is thus apportioned:—

Loss in Generator,	32·2 horse-power, or	28 per cent.
„ Receiver,	19·1 „	16 „
„ Line,	12·7 „	11 „
	64·0	

And the principal loss which occurred as above in the generator is thus distributed:—

Mechanical losses (friction, vibration, &c.)	8·5 per cent.
Power spent in producing magnetic field.........	11·0 „
Heating of the ring (armature).....................	8·5 „
	28·0

M. Deprez had, previous to the Paris-Creil work, made trials between Munich and Miesbach, and Vizille and Grenoble, transmitting through an ordinary telegraph wire, in one case half a horse-power a distance of 35½ miles, and in the other case 16 horse-power a distance of 32 miles. In the Munich-Miesbach trials Gramme machines were used for generator and motor. The total resistance of machines and line current (71 miles) was 1,900 ohms, the wire being of galvanised iron, 0·177in. (4·5 millimetres) diameter, a return wire being used. With a velocity of 1,500 revolutions of motor at Miesbach and of 2,200 revolutions of generator at Munich, the efficiency of the system was 60 per cent. In the Vizille-Grenoble trials from 41 to 62 per cent. efficiency were realised.

(*b*) *Pumping at St. Elizabeth.*—The surplus power of the engine of a ventilating fan at St. Elizabeth coal mines was used for generating electricity conveyed to a motor for pumping water at La Sorme for some boilers and farming purposes.

The distance between the engine and the pump was 775 metres (or about 850 yards), and from the pump to the farm and boilers 290 metres (or about 320 yards). The head against which the water was pumped was 20 metres (22 yards), and the quantity pumped 1½ litre per second, or about 20 gallons per minute.

(*c*) *The Cannon Foundry at Bourges*, in France, has employed Gramme dynamos for several years, as generator and motor in machinery for the testing of metals. There are also two 20-ton cranes for handling large ordnance, and these cranes are worked each by a special electro-motor supplied by current from a common dynamo. The power is transmitted about 130 yards, and about 13 horse-power are realised out of 25. The working has always been conducted without accident.

See also an account of an electric crane for foundry use at St. Ouen, in *Journal* Iron and Steel Inst., Vol. II., 1885, page 616.

(*d*) An electric installation for working stamping machinery at the *Phœnix Gold Mine* in Skipper's Creek, *New Zealand*, is interesting on account of the distance from the source of power to the Stamping Mill. Two large No. 8 Brush dynamo machines are used as generators, and a specially made Victoria motor is placed at the mill. The dynamo house is situated about two miles up the left branch of Skipper's Creek, where an open ground race of half a mile in length gives a fall of water of 180ft., the water passing down two wrought-iron pipes 22in. diameter, at the top and tapering to 6in. at the bottom. The supply of water is equal to working 10 stamp heads, but at present (Sept., 1886) the electric apparatus is required to work only four or five heads. Two Pelton water wheels drive the dynamos. These wheels are 6ft. diameter, exceedingly simple in construction, and make 300 revolutions per minute, developing 50 horse-power when in full work, and having, it is claimed, an efficiency of 80 to 86 per cent. The dynamos are driven at 700 to 800 revolutions per minute by belting from a countershaft driven by belts from pulleys on the spindles of the two water wheels. Each dynamo is said to be capable of maintaining 40 arc lamps of 2,000 candle-power, with an electromotive force of 2,000 volts and a current of 10 amperes, which is equal to an output of 26 horse-power from each machine, or 52 from both. By means of a switch-board different combinations of the two machines can be made, but in general they are coupled in parallel to the main circuit. This consists of two wires (one outward and one return, or earth wire) of No. 8 B.W.G., weighing each 433lb. per mile. They are carried upon poles as telegraph wires are carried, and the poles are also used to carry telephone wires connecting the mill and the dynamo house.

The motor runs at 350 revolutions per minute, and by a belt from a pulley on its main spindle drives the cam shaft of the Stamp Mill. The stamp heads weigh 8 cwt. each on an average, and the motor drives 20 heads at the rate of 70 blows per minute, and is said to be quite sufficient to work 30 heads.

This is the first instance of the application of electricity to the transmission of power in New Zealand, and it is expected that it will stimulate such work there, and be the means of utilising natural sources of power, although at some distance from places where that power is required.

(To be continued.)

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TAUSSIG'S AUTOMATIC FIRE AND BURGLAR ALARM.

It is not a little singular that the simple, effective, and inexpensive methods by which the aid of electricity may be called upon to supplement, or rather to forestall, the duties of watchman, fireman, and police, have as yet found so little employment in this country. In the great cities of America it is the rule rather than the exception for buildings of every description which are, or which contain, objects of value to be so protected. People are willing to pay heavily for the privilege of receiving an indemnity *after* a loss by fire, and a man who omits to insure his house and goods is considered rash to the extent of foolhardiness; yet he hesitates to incur a slight additional outlay in order to obtain the advantage of a safeguard, which practically amounts to the prevention which is emphatically better than the cure. This illogical position undoubtedly arises in the majority of cases either from ignorance of the existence of superior methods of safeguard, or from a doubt as to the reliability and efficacy of electrical apparatus for such a purpose. Under these conditions we are glad to avail ourselves of an opportunity which arises of giving a detailed description of one of the most simple although comprehensive systems which has come under our notice. On Tuesday last, at the Bow-street police station, by permission of Sir Charles Warren, Dr. Julius Maier gave a demonstration of a combined fire and burglar alarm, devised by Dr. Taussig, of Prague. This apparatus, which performs its duties in a perfectly automatic manner, may be employed either locally (that is to give warning within the premises attacked) or centrally to give warning at the police and fire stations. In the latter case, when once the premises have been secured for the night, the mere opening of any door or window with which the apparatus is connected, or a rise in temperature beyond the normal, automatically despatches a telegraph message, saying in so many words (by means of the usual Morse code), "Fire broken out at No. 40, High-street," or "Burglars at No. 18, King-street." The value of such a system is at once apparent, and we have now to describe the *modus operandi.*

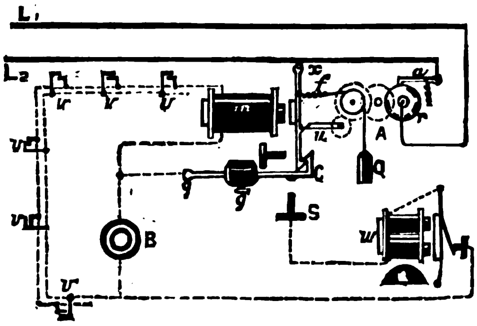

FIG. 1.

The premises to be protected are supplied with the instrument diagrammatically shown in Fig. 1. Here *m* is an electro-magnet whose coils are in circuit with a battery and a set of contact points, one of which is connected with each door or window in such a way that the opening of any one has the effect of breaking the local circuit. When this takes place the armature pivoted at x is pulled away from the magnet by the tension of the spiral spring *f*, thereby liberating the stop *u*. This stop is connected with a train of wheels which is driven by the weight Q. The weight now descends until the wheel *r* has made one complete revolution, when the local circuit is again closed by a cam (not shown), and the armature is restored to its initial position. Now, the external circuit L_1 L_2, by which the alarm is transmitted to the central station, is completed through this wheel *r*, and the contact point *a* which rests upon its periphery. It will, therefore, easily be understood how the message which has to be transmitted can be embossed upon the face of the wheel in the Morse code. Consequently the descent of the weight Q accomplishes the whole of the required duty. The parts C, *g*, S, and W can be fitted or not as may be desired, their object being to set an alarm bell ringing in any part of the same premises. The mode of action will be obvious upon an inspection of the figure.

For use as a fire alarm it is only necessary to place "thermostats" in the local circuit at suitable points, a thermostat being simply a thermometer, in which the rise of the mercury is made to *open* the circuit, which produces the same train of effects as before described. The advantage of obtaining the initial effect from the opening rather than the closing of a circuit will be apparent when it is observed that *the cutting of the wire of the local circuit* sets the alarm in action. This is obviously calculated to disconcert any individual animated by burglarious intentions, who, having acquainted himself with the existence of the alarm, thinks to circumvent its action by cutting the wire.

Before completing our description of the external circuit, one or two additional points remain to be noticed. First, the apparatus is set at night, and disconnected in the morning by means of a key, which can be used either from within or without the premises as may be desired. Provision is made for correcting a false alarm either by means of an ordinary Morse key communicating with the central station over the line wire, or, if preferred, by telephone. It is, of course, necessary at intervals to wind up the weight Q, and a simple arrangement is provided whereby if this is not done at the right time notice is given by means of a local bell which is thrown into circuit as soon as the weight touches the bottom.

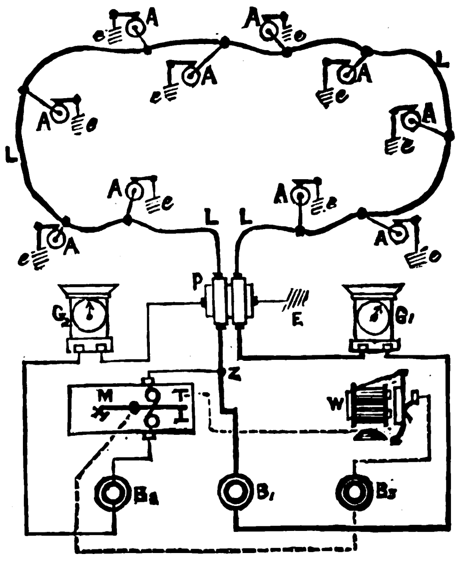

FIG. 2.

Fig. 2 shows the arrangement of the external circuit and the apparatus at the central station. The wires L L are carried round the whole circuit, passing through the lightning protectors P, the galvanoscope G, and the cell B. By means of the circuit thus formed, the perfect condition of the line wires is continuously indicated by the deflection on G. The automatic apparatus A A in each building are connected in parallel upon earth circuits; and in this circuit also is placed the battery B_2, the Morse recorder M, and the alarm W, which are all connected up in the usual way. It will be seen that the main circuit will still be complete, even if the wires L are broken at any point.

Finally, it will be apparent that the system readily lends itself for working in connection with any telephone or telegraph circuit which may be already in existence, and without disturbing the arrangements in use during the day. This feature ought to commend it to the several telephone companies, who should find it a useful adjunct to their present service.

PHYSICAL SOCIETY.—March 12.

Prof. C. CAREY FOSTER, Vice-President, in the chair.

Mr. SHELFORD BIDWELL described some experiments which seem to show that the electrical resistance of suspended copper and iron wires alters with the direction of the testing current. The apparatus used consisted of a metre bridge with coils of 100 ohms in the gaps adjoining the standard wire, the other two arms being two suspended wires united at the top, to which point one terminal of the galvanometer was joined. A commutator placed in the battery circuit served to reverse the testing currents. When a wire is suspended vertically the stress increases from below upwards, and the author believes the observed effects due to the absorption of heat by the current as it passes from a stretched towards an unstretched part of a copper wire, and the evolution of heat when it passes from an unstretched towards a stretched part. As the apparatus was arranged the current passed up one wire and down the other, heating the one and cooling the other, thus disturbing the position of balance. If iron wires were used, the heating and cooling effects are reversed.

Prof. S. P. THOMPSON suggested loading the wires at different points in order to vary the stress without using such long wires, and Mr. C. V. Boys thought still shorter wires could be used by joining the ends to a revolving spindle and stretching them by centrifugal force.

On a Lecture Experiment in Self-Induction, by Mr. SHELFORD BIDWELL.—A telephone is placed in series with the secondary coil of an induction coil, and another coil whose self-induction can be varied by inserting a core of iron wires, or another coil, or both.

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The effect of introducing the iron core is very marked, reducing the sound enormously. If a coil of wire containing an iron core be inserted, the effect of short-circuiting the coil increases the sound in the telephone. The same author also described and showed an experiment, due to Dr. Fleming, in which a disc of copper, inclined at an angle of 45° to the axis of a coil of wire and suspended tifilarly, is deflected by passing an undulatory current round the coil.

In explanation of the former experiment, Dr. FLEMING wrote down the formula for the effective resistance and self-induction of a circuit near another closed circuit, which showed that the former is greater, and the latter less for undulatory than for steady currents. He had not arrived at any satisfactory explanation of the deflection of the copper disc.

Prof. AYRTON exhibited a tuning fork worked electrically, in which the pitch could be varied by altering the self-induction of the circuit, or by varying the position of the make and break screw.

Mr. C. V. BOYS referred to his experiments, published in 1884, on the impulse given to metal discs suspended in a magnetic field whose strength is suddenly changed, as being of a similar character to that described by Mr. Bidwell, and suggested the use of aluminium instead of copper in future experiments, owing to its conductivity for the same weight being greater.

Prof. THOMPSON said he had recently used a similar apparatus to that described by Mr. Bidwell as an illustration of the effect of self-induction, and pointed out the uses of self and mutual induction in multiplex telegraphy and telephony.

As an explanation of the deflection of the copper disc by alternating currents, Prof. FOSTER thought it possibly due to its initial position being that of maximum sensibility, and therefore each impulse had less effect than the preceding one.

Mr. W. M. MORDEY mentioned a simple arrangement for varying self-induction used by M. Ferranti to control the power of incandescent lamps worked by alternating currents, and Prof. AYRTON described a closed magnetic circuit of great self-induction, used to protect voltmeters on the telpher line at Glynde from disastrous inductive effects produced by breaking the locomotive circuit.

Referring to tuning forks, Mr. BOSANQUET thought some self-induction was necessary in order that the current should act to the best advantage in attracting the prongs at the proper instant. Further remarks were made by Mr. BOYS and Prof. PERRY.

On a Lecture Experiment to Show that Capacity Varies Inversely as the Thickness of the Dielectric, by Profs. W. E. AYRTON and JOHN PERRY.—The authors consider it easy for students to see that, other things remaining constant, capacity is proportional to area. Taking this as proved, a condenser is arranged such that the area A of the insulated inner coating varies as the thickness t of the dielectric, and the potential difference between the coatings is found by experiment to be constant. Then, since capacity $= \frac{\text{Quantity}}{\text{Potential}}$, and both the latter being constant, therefore the capacity of the condenser is constant. But by the construction of the apparatus $\frac{A}{t}$ is constant, and it is assumed that capacity varies as A, therefore capacity must vary inversely as t.Q.E.D.

Note on Magnetic Resistance, by the same authors.—Two iron rings, about 6in. diameter, made from the same bar of best Swedish iron, about ½in. diameter, were wound with insulated wire in two halves, so that a current could be sent round either or both halves, and the resulting induction measured by the throw of a ballistic galvanometer placed in series with a few convolutions of wire wound round the outside of the main winding. One of the rings was continuous and the other had a small air space of about 8 mm. in a plane perpendicular to that of the ring, and passing through its axis as if the ring had been cut by a saw. The primary object of the experiments, which were made by Messrs. Aldworth, Dykes, Lamb, Robertson, and Lingler, of the Central Institution, was to determine whether there was any appreciable "surface magnetic resistance." The results do not show any such resistance, and the relative resistance of air and iron, as calculated from the unsaturated parts, are about as 1,200 to 1, a number agreeing fairly well with those obtained by other experimenters. From this the authors conclude that for small distances magnetic resistance of air is proportional to length. When the magnetising current was passed round the one half of the divided ring on which the test coil was wound a greater induction could be obtained than by any other way of magnetising, and this the authors do not attempt to explain.

Mr. BOSANQUET said he had always found greater induction obtainable in the middle of bar electro-magnets or open magnetic circuits than could be produced in closed magnetic circuits, and thought the above observations confirmed his own results.

A discussion followed, in which Mr. C. V. Boys, Mr. W. M. Mordey, Mr. Bosanquet, and Prof. Perry took part.

On account of the late hour, the reading of a *Note on Dynamo Machines and Motors*, by Profs. AYRTON and PERRY, was postponed till the next meeting.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

An extraordinary meeting of this society was held on Thursday, the 17th inst., and continued the discussion on Mr. Desmond G. FitzGerald's paper on "Reversible Lead Batteries and their Use for Electric Lighting," the first part of which appeared in our issue of the 18th inst. The president of the society, Sir Charles Bright, was unavoidably absent through indisposition, his place being taken by Prof. Ayrton. The Chairman, in opening the proceedings, referred in feeling terms to the death of the society's librarian, Mr. Alfred J. Frost, and paid a high tribute to the personal character and abilities of the deceased. He then called upon Prof. Forbes to open the discussion.

Prof. FORBES said that the principal point that he wished to draw the attention of the Society to was a small table which he had prepared containing some facts relating to tests upon the battery, to which Mr. FitzGerald had directed their notice :—

Rate of Discharge.		Capacity.	
Ampere per lb. of		Ampere-Hours per lb. of	
Plate	Cell.	Plate.	Cell.
·68	·41	9·2	5·5
·88	·53	7·1	4·3
1·2	·72	6·2	3·7
1·5	·9	5·5	3·3

Those tests showed the rate of discharge and the capacity which corresponded to that rate of discharge. They would observe from the table that when they diminished the rate of discharge they got an enormous increase of capacity. The curve which showed the capacity in terms of the rate of discharge was very remarkable indeed, rising very rapidly as the rate of discharge diminished; and many tests that were made with the battery in question were purely with the view of finding its practical value, and he did not prosecute any scientific tests to find the ultimate values. The form of the curve was so remarkable that he would like to ask Mr. FitzGerald whether he had made any tests with extremely low rates of discharge. The very lowest that the speaker had put down there was less than that of any other secondary battery which had come under his notice — a rate which could be taken out efficiently. But it seemed to him that if that curve went on in the same way that it seemed to be going that the capacity must be very much greater when they reduced the rate of discharge to a small fraction of an ampere per lb. of plate. He had made a good many tests with those batteries last year, and their lightness was one of the very remarkable features about them. They were lighter in point of capacity than any other which he had ever seen. The material itself, which Mr. FitzGerald had invented, was, as every member would see immediately, very remarkable indeed, and was mechanically good. A person who had what Mr. Crompton called an "eye," looked upon the material with appreciation. It looked like the right sort of stuff for its solidity, and seemed as if it were a durable material. Of course one could not tell by simply making tests for a few months whether it was going to have a long life, but while he had had those batteries under his supervision he had taken care to look for all the plates that had been in use for years, and all of them, however old they were, seemed to be just as good as when they were new. Another fact which he discovered, which was a casual observation of the same sort, and was not perhaps of very much value, was this, that he was never able to get any white sulphate on them at all, so that he must say he felt that Mr. FitzGerald had made a very great stride indeed as to secondary batteries in inventing that anode, and he was sure that the more tests were made with it, the more they would be appreciated. There were some other points in connection with the battery, independent of the lithanode, of some importance—as for example, the manner in which it was supported in the cell was different from that of all others. Then there was the use of mercury for contact, and again there was the employment of a celluloid in the battery, with platinum for making contact. As to the mercury, one had generally an objection to using it for a permanent contact, but he did not think it was a very serious objection, and as far as he could see it was adopted only because the inventors of that battery had thought it was more convenient to have a mercury contact in spite of such objections, as it might possibly have sometimes in preference to ordinary contacts, which were certainly liable to become imperfect sometimes, and lead to a very great deal of trouble; and all of them who had used secondary batteries knew that they experienced great trouble sometimes from imperfect contact of the plates in a cell. He would like Mr. FitzGerald to give them a little more information than he had done about the celluloid, which seemed to be an extremely valuable material for battery work, and seemed to be also very easily worked. Of course, to use a platinum contact was rather an objecton on account of the expense, but that seemed to him the only objection to the battery. He had said that the result of his tests was most undoubtedly to lead him to think that Mr. FitzGerald had made an enormous advance in secondary batteries. But there was one point which had puzzled him very greatly, and which seemed to add a new feature to the battery before them. They all knew that when they charged a secondary battery—an E.P.S. cell, or any other—they had what might be called a spurious electromotive force; that

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was to say, they had the natural electromotive force, which was exactly 2 volts; but at the first moment they used it after charging it they found that the electromotive force of the cell was at least 2¼ volts, sometimes a little more than that. It followed from this that during the time that they were charging up the cell they were charging against an electromotive force of 2¼ volts, and when they discharged it, it was only at its natural rate of 2 volts, because its electromotive force disappeared almost immediately. Therefore, neglecting all other causes of loss of efficiency in a secondary battery, they had simply, owing to this cause in itself, a loss of efficiency in the ratio of 2¼ to 2. Now, with the cell before them, in the whole of the tests which he had made he had never seen any spurious electromotive force like that. The highest electromotive force which he had ever got from a cell immediately after charging it had never been as much as 2·1—considerably under 2·1—and the terminal electromotive force when he was charging it, which was of course dependent on the resistance of the circuit, was never in excess of 2·15. It seemed to him to be an enormous advantage that had been gained in the present cell that, instead of having an unnecessary loss from this cause, it could scarcely be detected. The ratio was certainly not more than 2 to 2·1. He had had a great many batteries to test at different times, but he had never seen one come out with the same result. What was the reason of it he could not say. The general assumption as to the cause of that spurious electromotive was that it was owing to the hydrogen bubbles sticking to the plate. Whether that was the true cause or not, he would rather not say. The subject had become intensely interesting to him since he had noticed this feature of Mr. FitzGerald's anode, and he would investigate it more fully later. But if it was due to the bubbles of hydrogen, then that depolarising action, as they might call it, seemed to be something like the action of a plate in a Smee cell, that the surface of the plate seemed to have an action in allowing or not allowing of the hydrogen bubbles attaching themselves to the plate. Those were all the points that he had to draw attention to, but in common with every one he was sure he must congratulate Mr. FitzGerald most heartily in having produced a plate which was certainly a great advance in secondary batteries.

Prof. SILVANUS THOMPSON said he had a very few remarks to make on Mr. FitzGerald's paper. He wished to deal with the chemical question which it raised, and which was partially discussed at the previous meeting by Dr. Gladstone and Mr. Preece. But before doing so he had one or two remarks to make in relation to other parts of the paper. Thanks to the kindness of the Primary Battery Company he had had a small cell in his laboratory for some months, and from time to time he had charged and discharged it, and it behaved extremely well, though it was not quite so light as the cells that were now shown to the society. When he said it had behaved well, he meant to say that it had not performed any awkward tricks. Buckling had not occurred in the plates, only in the celluloid frames, and that not to any great extent, and there was no sign whatever in the lithanode plates. He must confess, however, that he was a little disappointed when he came to work with it on finding that he could not get as large a discharge from it as he had expected, having regard to the size of the surfaces of the plates. He did not want to speculate on what he had not really tested, as he might have done if he could have given time to it, but it seemed to him that a higher rate of discharge for a given surface of those cells would be obtained if the electrode, or, rather, the metal that was in connection with the lithanode, were of a little larger area. Now there one came across a certain practical difficulty, because Mr. FitzGerald, with the express object of avoiding local action between the peroxide and the lead that had been used hitherto, had adopted a platinum contact. That gentleman had certainly very ingeniously reduced to a minimum the cost of the platinum support, for the two strips of platinum foil that went down behind the lithanode plate could not cost very much; but the speaker thought that in having such an extremely small amount of platinum in contact with the lithanode something had been sacrificed. His impression was that the lithanode, though it was a substance possessing other advantages, as well as being an electrolyte, was not so good a conductor that they could afford to introduce it into the battery, the resistance of which would be very greatly reduced if they had a frame all round the edges of it, or a grid fixed through it, so that there might be a more extensive surface of platinum connected with it at the contact. As shown, the current had to run clean through the lithanode plate from the place at which it entered, where the chemical action took place, and there was a serious resistance as compared with the small resistance that one encountered in other cells, and he believed that this was why one did not get a large current from batteries of that surface. He did not think he was wrong in saying that from an equal area of surface in the battery they could not get the same discharge current as when the plates had grids round them. If he were wrong he would be glad to be corrected. He certainly saw no trace of the formation of white sulphate, but he must entirely disagree with Mr. FitzGerald on the sulphate question. He did not think that there could be two opinions about the essential badness of a plate that was all white with sulphate, but they ought to bear in mind that there were two sulphates of lead, and that both might occur in a secondary battery. There was a certain grey sulphate of lead, if he might so call it—a semi-transparent substance—grey not white, and that substance was $Pb\ SO_4$. Either to oxidise or to reduce the grey sulphate was not a hopeless task, but if they carried the point of discharge below a certain point they got $Pb_2\ SO_5$, which was a much whiter substance than the simple sulphate of lead, and which, if it occurred to any extent in a cell, was absolutely detrimental, for it did not reduce when they had hydrogen bubbles coming against it, neither did it oxidise at the other end of the battery, and simply choked the cell, falling out in the form of a powder. Of course they got the other sulphate along with it, but this basic sulphate was a truly hopeless substance in the cells. There was a question that he would like to hear discussed. He thought they really possessed very little information about it. Suppose they had a fully charged cell, and let them consider the peroxide end—he did not like to call it the positive, as they usually did, because Mr. FitzGerald called it the negative—he meant the plate that was of a ruddy-brown colour. Now, if they had one of those fully charged ruddy-brown plates, and they began to discharge it, in what way did the discharge begin? Did it begin on the front surface, or did it begin on the back, or did it begin simultaneously all through? He could quite believe that if they had plates of one degree of density one thing might happen, and if they had plates of another degree of density another thing might happen. Those pieces of lithanode were marvellously dense, and he thought with the denser quality of lithanode the action would begin outside rather than inside. With a porous kind of substance he fancied that the action would begin nearest the support, and the only piece of evidence that he could offer on this point was from what they saw in the behaviour of other cells. When one took an ordinary piece of sheet lead and pasted it over with a prepared paste of red lead and sulphuric acid, and put it into a cell and began to charge it, they found unquestionably that the action began at the core, and ended at the outside. He wanted to know whether, in the process of discharging in the case of this cell, the reduction began at the surface, or right through, or next the support. There was another matter he thought worth discussing; that was, whether the scum that was referred to last week by some of the previous speakers, and which was formed over the surface of the lead supports, and which some believed, as he himself did, played an active part in protecting those supports from being bitten into and eventually destroyed — whether that scum was sulphate of lead. They assumed last week that it was. He had hitherto assumed that it was, but he had noticed again and again that the scum that they met with was not of the true colour of sulphate. It was generally of a darker hue, and whether it really was sulphate he did not know. He would like to have the opinion of others upon the point. There was an extremely beautiful experiment made by Prof. Oliver Lodge, and recounted in the Cantor Lectures, which had some relation to this subject of scum. Prof. Lodge was recounting certain facts about Planté's old process of formation about charging and recharging, and reversing and charging again, and he pointed out that if they took two plates of lead that had never been used before and passed a current through them so as to slightly peroxdise one, the other, as they all knew, did not get bitten into at once. Hydrogen bubbles played over it, and the surface became slightly hydrogenised, and if they discharged such a pair of plates, the reduced plate having a mere film of hydrogen over it was exhausted in a few seconds. Prof. Lodge set two strips to ring an electric bell, and found that the action stopped almost instantaneously, and the bell ceased to ring. Why? Not because the peroxide had given up all its oxygen, but because the lead plate had become covered over with scum. Then he found on putting a piece of zinc into the liquid the scum was seen to disappear almost like a flash of lightning, and the bell went on ringing for 10 or 15 seconds longer. Lead apparently refused to burn or be consumed in sulphuric acid when it presented a smooth surface. There were two or three remarks made by Mr. Preece last week to which he wished to refer. Mr. Preece recommended the use of hydrometers in keeping a check on the charge of the cell, and on the general state of the cells. He (the speaker) could heartily endorse that recommendation, and he knew, as a matter of fact, that hydrometers had been used by the older experimenters. Indeed, he thought he was not mistaken in saying that the Electrical Power Storage Company produced little forms of hydrometers, made thin and narrow so that they might go down between the plates of the cell. This hydrometer was a most excellent thing to work with, and was a scientific check on the state of the cells. But when he endorsed those remarks of Mr. Preece he must differ from that gentleman as to the exact figures that were given. Mr. Preece stated that the hydrometer when charged would have a density of 1,210 as being the right strength of the acid. Now, the particular variation which Mr. Preece found with his cells was by no means found when they came to deal with other cells. The variation of the density of a cell depended on the withdrawal of acid from it. If their cell had a certain number of plates on it there was a certain amount of acid and a certain density. As soon as those plates were discharged they would become sulphated to a certain extent, and he granted that if they discharged those plates from the same point to the same point they would take up the same amount of sulphuric acid, whether they were in a big box or a little one. But it made all the difference in other circumstances; as, for example, if it were a box of relatively large capacity there would be a relatively large quantity of water there, and the withdrawal of acid from it might not be the same as it would be if it were a small box. The change of density depended on the reservoir of water that they had all round it. Therefore, Mr. Preece's figures must not be taken without due consideration as to what they meant. Another point he wished to notice was the chemical formula which Mr. FitzGerald brought before the Society, and which Mr. Preece seemed to think was the end of all things, and explained everything. He (the speaker) accepted it up to a certain point as representing chemical facts; but he thought there was a great deal more to be said on the chemical question. Indeed, they might say that the chemical question was capable of being settled on an absolute basis. Why did an accumulator give them an E.M.F. of about two volts? That was purely a thermo-chemical question. Why did a Daniell cell give them only about 1 volt? That was a purely thermo-chemical question. They knew this, that taking the equivalent quantity of zinc, and causing it to be consumed in sulphuric acid, and changed into zinc sulphate, the quantity of heat given out of the zinc was represented by 85,400 calories, whereas the data of a similar quantity of copper was 37,520 calories, the difference being 47,880, and seeing that 46,000 calories corresponded to one volt, it followed that the E.M.F. of a Daniell cell was a little over one volt. If they could calculate from the known thermo-properties of zinc the E.M.F. of Daniell cells, they ought to be able to calculate precisely—if they knew

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the chemical data—the E.M.F. of accumulators of any sort. If they knew the E.M.F. of an accumulator to be 2 volts and over, that very fact decided that the thermo-chemical data should correspond to that chemical force. What were the various hypotheses that had been propounded? He thought he knew of five. (1) Some people said that the E.M.F. in an accumulator was due to the reduction of peroxide of lead to spongy lead. This was rather a wild hypothesis. According to this view they had a sort of electrolytic action going on and hydrogen given off at the peroxide end reducing the peroxide to the state of spongy lead. But, if so, this meant that the oxidation of spongy lead at one end brought the oxide at the other up to the metallic state—reduced it to its highest state of chemical activity. It was rather curious that the one end should run up to the other. That, however, was the first hypothesis that was put forward. (2) The second was that the peroxide was reduced from its condition of oxygen activity by the sulphuric acid, becoming lead sulphate. (3) The third hypothesis was that at one end the lead went to lead sulphate, and at the other end peroxide was reduced to spongy lead. (4) The fourth hypothesis was that both the plates went to sulphate. At one end Pb eliminated hydrogen from H_2SO_4 and became $PbSO_4$, while PbO_2 gave out its oxygen and took up SO_4 at the other end. (5) The fifth hypothesis was that at one end the peroxide went down to monoxide, virtually to litharge, and at the other end Pb also went down to monoxide, after which both monoxides were attacked by sulphuric acid, and both became $PbSO_4$. Now of all these hypotheses, which was the correct one? If they knew the thermo-chemical data they could tell which was the true one. It was only a question of knowing the facts. Let them take the first, and calculate on that hypothesis the thermo-chemical heat values of the reaction, and afterwards translate these into volts. According to Jscheltzow, the calories for the first four hypotheses were respectively 37,200, 81,500, 44.300, and 88,6C0, the corresponding volts being 0 81, 1·77, 0·96, and 1·93. The last seemed to be nearest. But his own view was that though sulphate was formed at both ends, the action of sulphating, though chemically inevitable, was *non-adjuvant*; that is to say, being chemically similar at both ends of the cell, it added nothing to the useful electromotive forces. His own calculations for the *adjuvant* part of the reactions on the fifth hypothesis gave as the net result 102,700 calories, or 2·2 volts. In conclusion, he referred to an experiment of Planté's, which demonstrated that the solution of copper in sulphuric acid in a voltameter with copper electrodes took place distinctly in two stages—oxidation first, then solution of the oxide in the acid.

Mr. J. S. SELLON said it was his great desire not to be thought hyper-critical as to the work of others. His one wish was to see the development of the science in connection with storage batteries, and he was extremely glad that so many should be working towards that object, inasmuch as it had so intimate a relation with the success of the electric light in the future. With regard to the statement that had been made that the storage battery was yet in its infancy, if that were so it was certainly an infant of elephantine proportions. He was inclined to think that it had passed the stage of its infancy, and arrived nearer to that of manhood. Of course he was anxious to see great improvements, in the shape of greater capacity and lessened cost, but he feared that the only way by which that could be attained was by better manufacture and better management in the use of what we have to hand. He was strengthened in that view by the fact that although for years past electrical scientists throughout the world had been at work trying to perfect secondary batteries, no great change for the better had been achieved since 1881, and he was therefore, as he had said, inclined to look for improvement rather in the direction of improved manufacture and manipulation. With regard to the table of figures given by Mr. FitzGerald as to the storage capacity of various secondary cells, he could only say that the highest of them in no way surpassed those attained in early days—a fact to which he would refer later on, when he would give some figures that had been furnished to him by the Electrical Power Storage Company. It was not his intention to trouble the Society with any formulæ on the subject of sulphating after the elaborate way in which Prof. Thompson had dealt with it. The simple law which they had to deal with was the fact that as the peroxide degenerated by loss of oxygen to the lower states of oxidisation, in proportion to those lower degrees so must sulphating take place, and neither argument nor variable methods of manufacture could affect that law, which was a chemical, not an electrical one. In passing on to the question of capacity, he would first allude to the two points of practical interest and useful discussion in connection with the paper, namely, the utilisation of solid peroxide plates, and the practicability of furnishing the electric light to private houses from storage batteries. On the latter of these points he had propounded views not long ago, and he had not since changed them. Indeed, the figures he had hastily put together gave much latitude to the credit of the scheme. He did not exhaust the list of difficulties to be encountered. It seemed to him to be very imperfectly realised that the satisfactory working of a battery depended materially upon the uniformity of the electrolyte. Its strength should be properly adjusted, and such adjustment should be maintained. Now, in the varying state of the replaced plates as proposed by Mr. FitzGerald this became impracticable. All sorts of difficulties would occur. Much as one would like to see the system of daily delivery flourish, he was afraid they must look upon it as outside the range of practical probabilities. As to the utilisation of solid peroxide plates, and the statement that by their use, a larger capacity could be attained by a given weight, and that greater durability was also secured, his reply was based on results obtained many years ago, and it was this—that a great capacity under the normal conditions of work, though it might be at first obtainable, was not maintainable. The difficulty which supervened was the rapid clogging up of such plates, and the proportion of inert material of oxide and sulphate essential to give stability to such a plate was so great relatively to that of the active material that there was no economy from the starting point. The resistance throughout the mass was so varying, consequent upon the localisation of the conductor at one point, as pointed out by Prof. Thompson, that unequal work was the result upon the different parts of the plate. The consequence was that the plates degenerated in a comparatively short time, and lost their power. It stood to reason that it was more advantageous to have a good conducting medium distributed evenly throughout the active material than to have only one strip down the middle and a large mass of inert and comparatively non-conducting material. As to local action, it was a bugbear that he did not allow to be a factor in the question. It was simply a matter of care in the manufacture and treatment, which experience had to guard against. Through absence he had been unable to refer to his old figures, and those which he wished to give with reference to the storage capacity of secondary cells were furnished to him just now by the Electric Power Storage Company. They were as follows:—"It appears that Mr. FitzGerald has never taken an E.P.S. L type cell himself and given it a fair test against the lithanode, but he takes the value of 41lb. of lead in the E.P.S., which will give the horse-power-hour on Geere Howard's statement. I have made some examination into the reports as to weight, &c., of this company's plates, and find that in a complete positive—of course he means the peroxide or positive pole-plate—weighing 5lb. the PbO_2 in the form of paste weighs only 25 ounces. Taking eight peroxide plates we have 200 ounces, or say 12½lb., of peroxide to produce the horse-power hour—say 375 ampere hours. This gives 30 *ampere-hours per pound of peroxide.* Mr. FitzGerald's lithanode, by his own statement, will give 16 ampere hours per pound. The lithanode is, therefore, at a disadvantage with the peroxide contained in pasted plates in the proportion of about two to one, and it is thus evident that, except for purposes of portable batteries, the material is a positive retrogression. Mr FitzGerald did not give the specific resistance of his material, but states that it contains about 70 per cent. of peroxide. If the remainder simply consists of sulphate, the specific resistance of the plate must be very high, and in addition to this we have the poor contact at the platinum strip, after discharge for a short time. The normal output per pound which is advised by us may be exceeded, but our usual 'pass' tests of a set of batteries is when one 15 L type taken at random will easily give 400 ampere-hours when discharged to 10 per cent. fall of electromotive force. This 400 ampere-hours, divided by the weight of peroxide in the grids, gives about 30 ampere hours per pound, and it is evident, then, that we make twice as much use of our peroxide, even under the worst conditions, as Mr. FitzGerald does of his lithanode under what we will presume to be the best conditions. When peroxide is tested under the best possible conditions in a grid—and I wish you especially to note this, which confirms my earlier experiments—we find that 25 ounces will easily give 84 ampere-hours. This is at the rate of 47 ampere-hours per pound of active material." It appears evident that the difficulty of working a solid peroxide plate is the difficulty of utilising any reasonable proportion of the material of which it is composed—a large portion of the interior containing four-fifths of the plate is comparatively inactive, and the conductive power is, of course, diminished in proportion to the clogging up of the sulphate.

Mr. F. V. ANDERSEN desired to make a few remarks in regard to the figures given in the paper. He said Mr. Sellon had already shown the far greater output from the peroxide of lead which is obtained in the E.P.S. battery—in fact, over 100 per cent. more than in the Union cell. He would now draw attention to the figures given in the paper in reference to the rate at which the new battery would work, and compare that rate to that at which the E.P.S. battery would discharge. Prof. Forbes had stated that the Union battery would work at a higher rate than any other secondary battery; but this was certainly incorrect, if the figures in Mr. FitzGerald's paper were to be taken as a basis. The rate of discharge for the Union cell is given in the paper as ·257 ampere per lb. of battery, and, as far as one could understand from the paper, that was the rate that corresponded to the storage capacity shown on the tables. We might safely take the average potential during the useful discharge as 1·95 volt. The rate of discharge of the Union cell was, therefore, equal to ·5 watt per lb. of battery, and there being 746 watts to 1 horse-power, the rate at which the battery would work was $\frac{1}{1492}$ horse-power per lb. of battery, which meant that to be able to work with a Union battery at the rate of 1 horse-power we should require a battery weighing 1,492lb. But if we took the 22lb. E.P.S. battery mentioned in the paper, and which in regard to storage capacity was found by Mr. FitzGerald to be somewhat heavier than the Union battery—which it naturally might be since it had lead grids in both plates, while the Union battery had no leaden frame at all in its negative plate—if we considered this E.P.S. battery in regard to the rate at which it worked, we should find it far superior to the Union battery. The E.P.S. 22lb. cell discharges at the rate of ·68 ampere per lb. of battery, *i.e.*, 1·33 watt, or $\frac{1}{561}$ horse-power, which meant that an E.P.S. battery to work at a rate of 1 horse-power would weigh 561lb., as against a Union battery weighing 1,492lb. The question now was—Would it in ordinary practice be of importance that a battery could store a little more energy in a certain weight of material than another one, if this latter were so much in advance of it in regard to the rate at which it would discharge? We should look at the example given in the paper towards the end in connection with a scheme for "electric lighting on a small scale." It was there proposed to supply customers with a Union battery which would run three 20 candle-power lamps for five hours, and it was said that this battery would require to have a storing capacity of 1 horse-power-hour of energy. It might be doubted whether the 1 horse-power-hour of electrical energy would run these three lamps more than 4 hours; but suppose the five hours were correct. Since we were to expend 1 horse-power-hour of energy in the course of five hours we should work at the rate of $\frac{1}{5}$ horse-power, and the Union battery required to do this would weigh $\frac{1492}{5}$

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=298lb. Now, since 60 per cent. of this weight was plates, the weight of plates wanted in this business was not, as indicated in the paper, 45lb., but it was ·6×298=179lb. It was quite true that if the required amount of energy, namely, 1 horse-power-hour of energy, was stored in the 45lb. it might be sufficient to charge one quarter of the battery each day, but the weight of the battery to be employed would certainly have to be 298lb. But compare with this the E.P.S. battery. The weight of battery required in this business was only $\frac{561}{5}$ =112lb., and of this only 50 per cent. is plates, so that the weight required was 56lb. if we use E.P.S. battery, against 179lb. if we were to use the Union battery. He therefore thought that the apparent advantage in the storing capacity was far outweighed by the insufficient power of the Union cell. Now, he would remark that the total weight of peroxide in the 22lb. E.P.S. cell was 2·261b., the cell giving out 75 amperes. It thus gave 33 2 ampere-hours per lb. of peroxide, as against 16 in the Union cell. He said that the reason why the Union cells could only work at so very low a rate, and give out so small a discharge, was evidently the very insufficient connection they had with their peroxide by means of the small platinum strips across the centre of the plate.

Mr. Bernard Drake thought the question with regard to this new battery, from the consumer's point of view, was one of first cost and durability. What people wanted to know nowadays was whether they could obtain a cheaper battery, which would give them reliable results in working, and entail no trouble. Time alone would show whether the battery before them met these requirements. Mr. Sellon complained that progress in improvements in secondary batteries was slow. If this was so, the reason was that whenever modifications were made it was necessary to wait many months before any idea could be formed as to whether the alteration was an improvement or not. Even then experience had shown that one was almost certain, if guided by any single experiment, to fall into some error ten times worse than the one which was being rectified. He thought it impossible to determine a fixed output for each maker's cells, as anyone could increase the capacity at the sacrifice of durability. For instance, with the E.P.S. form it was usual to vary the output between four and six ampere-hours per pound of plate. The figures given by Mr. FitzGerald seemed to include the connections as well as the plates. This, the speaker also thought, was not a fair basis for comparison, as the connections were often made larger than necessary in order to reduce the internal resistance of the whole battery, the resistance of the connections being quite as serious a consideration as the internal resistance of the cell itself. He was glad to see that Mr. FitzGerald agreed with the theory propounded by Mr. Gorham and himself at the meeting of the British Association as to the grid being protected by a dense coating of peroxide. This conclusion was arrived at after a great number of experiments, and he was of opinion that the protecting coat was almost, if not perfectly, dry when a plate was in good condition. If a plate was exhausted, he thought the coating of peroxide became moist and local action immediately took place. Prof. Forbes had shown a table of some tests with the lithanode plates, in which the capacity of the cells varied considerably, according to the rate of discharge. Had Prof. Forbes taken into consideration in these the recuperative power of the cell? He thought the capacity was not materially affected by the rate of discharge, provided the cell was constantly allowed to recover itself. The proposal to carry the plates backwards and forwards to a charging station was very similar to the temporary lighting with which he had had considerable experience. Although the figures as to cost incurred on any one trial installation would seem to show that this class of work might be undertaken and made to pay its way, yet, as the result of a whole season's working with about twenty-five tons of cells, he had found that the price would have to be such as would prohibit any very general use of the system. Mr. Sellon and his engineer had given them comparisons between the E.P.S. and the lithanode plates. These were scarcely to the point, as the whole of the capacity was taken as coming from the active material alone in the E.P.S. plates, the weight of the grids being omitted entirely, whereas about a quarter of the total capacity could be obtained from the grids alone left unpasted. Prof. Thompson's explanation of the battery was both clever and interesting.

Mr. W. H. Tasker remarked that Prof. Thompson had drawn attention to the low rate of discharge of the cell before the Society, but he (the speaker) thought that when they came to compare the rate of discharge with the surface of the plates it would be found that it was equivalent to ·016 ampere per square inch, which was as high as that of any other cell.

Prof. Ayrton said he would like to make a few remarks on the subject under discussion, because his colleague and himself had been interested in accumulators from their earliest introduction into England; in fact, the unnamed results of tests of the Faure accumulator given by Mr. FitzGerald in his tables were obtained by his colleague and himself in 1881. With reference to the question raised by Mr. Drake as to whether the storage capacity of a cell was greater or not when the rate of discharge was varied, it was an important subject, but it was, of course, impossible to criticise those results in the absence of Prof. Forbes, though he thought that the suggestion which Mr. Drake had raised was to the point. It was possible that Prof. Forbes was entirely mistaken in not taking into consideration the resuscitating power of the cell. If they wanted to find out the total storage capacity of a cell it was not sufficient, as shown by himself and Prof. Perry in 1881, to measure the current until the cell gave off no electricity. They must insulate the cell for some time, and then try again, and see whether the next discharge was comparable with the first, then insulate again, and make a second, third, fourth, or fifth discharge. He would like to ask whether with the tests with the Union cell it had been observed, as was found with an E.P.S., that the discharge remained steady for a long time, and then dropped off suddenly, or almost suddenly, to nought, as if there was an emptying of the cell—in other words, whether there was a gradual or sudden falling off of the discharge, and whether, when it did fall off, it was due mainly to an increase of resistance, or to a diminution of E.M.F. They were most deeply indebted to the Electrical Power Storage Company for the energetic way in which they took up and continued to solve what seemed originally to be a rather hopeless problem, and the very great success they had attained. But while expressing his deep gratitude to them he had to criticise something—a very small thing—and that was the introduction of the expression, "horse-power-hour." That was, he ventured to think, a most delusive expression, because it really did not tell them anything. It was very much the same as if they said when buying a watch that they were living at the rate of £100,000 a year for one minute. That gave no idea of what their income might be. They did not want to know what was the horse-power that the cell could theoretically give out if discharged in a minute or second, as it was physically impossible to take the energy out of a cell at any such rate. That told them nothing about the cell. What they wanted to know was this—at what rate they could discharge a cell with safety; at what rate would the maker allow them to discharge a cell; how many amperes per pound weight could they take from a cell, or how many watts per pound would the maker allow them to take from it, and for how long a time could this rate of discharge be maintained? Perhaps it might be better to express it per £. sterling. They desired when they bought a certain article to have the amount of the cost expressed in money value, and they wanted to know for every sovereign of their money spent in prime cost how many amperes or watts they could get in exchange and for how long a time. That seemed to him to be a far more satisfactory way of expressing it. Certainly they must not deal with horse-power-hour, and call this and that so many horse-power-hours. With reference to the most interesting remarks of Prof. Thompson, he would refer to only one part of them, and that was where Prof. Thompson had spoken about what was the chemical action that took place in a cell. He (Prof. Ayrton) did not quite agree with Prof. Thompson, but felt sure that he disagreed with Prof. Thompson probably because he had misunderstood him. The point he wanted to know was this: Did Prof. Thompson think that, at the beginning, when a cell was discharged, there was a sulphate formed on both plates, or only after a certain time? If there was not a sulphate formed on both plates at the beginning, then it was quite right that there was a totally different chemical action at the beginning from what there would be after a certain time. But if Prof. Thompson took the view that was commonly adopted, that there was a sulphate formed on both plates at the beginning of the discharge, then he (the speaker) did not see that it helped them much in considering the two stages in which the sulphate might be supposed to be formed, because they had not merely to consider the first change—the PbO_2 changing into PbO, and the PbO changing into PbO_2—but they had to take the second action, and if they did that they would come to the same thing — the fifth action he thought it was. If Prof. Thompson took the view, which he probably did, that sulphate was not formed first of all, then he had given the complete action. But if sulphate was formed at first on both plates he did not see how it would help them in calculating the first part of the action and neglecting the second. Mr. Drake was quite right in saying that it was very difficult to make money by carting about accumulators. He thought that Mr. Drake might possibly be misunderstood when he remarked that it did not pay on a large scale. Usually things did pay on a large, and not on a small scale. He fancied what Mr. Drake meant was this: that in certain cases people wanted the electric light in their houses for a ball and such like purposes, and were willing to pay a relatively large sum for one evening's lighting, and under those circumstances it would pay quite well to cart the accumulators, but there were not enough people willing to make it pay on a large scale. Mr. FitzGerald had given them an illustration of sending a half-penny worth of milk, but they all knew that when the milkman went his rounds he did not take his milk back again. Of course some weight must be allowed for the can. But the weight of the useless thing in the milk example was not great compared with the useful thing, whereas in the electric case the weight of the useless thing, the accumulator, was infinitely great compared with the useful thing, which was the electric power, which of course could not be weighed. The only case that he thought of at that moment, where the weight of the thing taken back again was enormously great compared with the weight of the thing they paid for, was where people bought compressed gas that was sent in very heavy iron cylinders, for the difference of the weight of the empty and full cylinder was almost inconsiderable compared with the weight of the cylinder itself. But the compressed gas industry was very small compared with the milk industry. It was almost like buying a precious jewel, when they did not think of the weight of the jewel but of that of the case. He had only one other point to remark upon, and that was the subject of names. He would suggest that it would be well for the nomenclature committee to settle what should be the names given to the poles in the accumulators. Of course the difficulty arose from the fact that a current went both ways in accumulators—one way in charging and the other way in discharging. Some people thought of the charge and others of the discharge, and the names were alternated. He was not sure that Faraday, great as he was in suggesting names, was particularly happy in the words anode and cathode. If a wire went up from the bottom the current also went up, and went down when it left; but as they all knew, in modern voltameters the current went up at the *cathode*, the pole where from its name the current "went down," and *vice versâ*. If that difficulty was met with the ordinary voltameter one could easily perceive the difficulty that there must be when they had to think of charging and discharging, and the probable solution would be to drop both "anode" and "cathode," "positive" and "negative," and suggest other names altogether, and give one appellation to one plate, and another to the other plate. The plates did not change, and therefore there need be no confusion when they were talking about charging and discharging.

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Mr. FitzGerald, in replying to the general discussion, said that the most important thing that he had to say that evening was to correct an error which he had been told he had made inadvertently at the end of his paper. He referred to the weight of the battery boxes, which he had given as 10, or a little over 10lb. He meant to say double that weight, namely, 20lb., or a little over that figure. He supposed that nobody there expected that he should answer all the points of interest, or even one per cent. of them that had been brought forward in the course of the discussion. If the members expected that, they were doomed to be disappointed, for he felt himself as though he would require two or three days to take in everything that had been said, and there now remained to him only 10 minutes time in which to make his reply. He had made a few notes, however, in reference to the remarks that had been made by Dr. Gladstone at the previous meeting. He had come to the conclusion that Dr. Gladstone and himself were substantially in agreement. He would seem to have misunderstood the meaning of the words used by Dr. Gladstone about the formation of an almost impermeable coating between it (the peroxide) and the first metallic plate. In his paper he admitted that the clogging up of the interstices in the peroxide might be beneficial in reducing local action. As Dr. Gladstone had said, there might be more than one explanation of the phenomenon observed, and it might be safely concluded that in the case of peroxide elements a lead support local action was impeded, when the peroxide was not impervious to the electrolyte, by the formation of lead sulphate in the openings or interstices through which the electrolyte obtains access to the metal. Or again, local action might be impeded, as in the case of the wonderful Planté cell mentioned by Mr. Barker, and as in the plan advocated and adopted by Messrs. Drake and Gorham, by the formation of a very impervious layer of oxide. In regard to another matter, he thought they might safely accept the formula of Dr. Gladstone and Mr. Tribe, with one modification, as the electro-chemical formula representing the initial action occurring in the discharge of a lead secondary cell—that action which almost obviously, he thought, subsequently became complicated by another, as yet only guessed at, which had the effect of reducing the E.M.F. of the cell. The modification in the formula he referred to was that of taking hydrated sulphuric acid instead of water as the electrolyte, and of admitting consequently that the lead and the positive element entered into combination directly, instead of indirectly, with SO_4. The ultimate result was still expressed by the equation $PbO_2 + 2H_2SO_4 + Pb = 2PbSO_4 + 2H_2O$. In regard to the observations made by Mr. Preece, he appreciated the importance, theoretically as well as practically, of careful observations with the hydrometer and with the voltameter simultaneously, although that instrument had not often been used by him (the speaker) in his methods of investigation. Such observations might indubitably throw light on some of the questions which he had suggested, especially on the subject of the quantity of acid which entered into the combination with the lead on the peroxide plate. Mr. Preece intimated that a more extended experience of storage cells on his (Mr. FitzGerald's) part would prove to him that the formation of white sulphate on the negative element was a necessity. As he had endeavoured to explain, so far as his recent experience had gone, it was in the directly opposite direction. He had found that the production of white sulphate—of non conducting unmixed sulphate—was not a necessity. He had charged and recharged sixty or eighty times the same lithanode elements, and he had never detected any formation of non-conducting sulphate. This had been also noticed by others. As Prof. Silvanus Thompson had pointed out, sulphate was undoubtedly formed on the plates, and could be dissolved out. But it was produced in admixture with peroxide of lead, so that the plate never lost its conductivity, and the sulphate was in a condition to be readily peroxidised instead of being in compact dead masses, which, as they all knew, were exceedingly difficult to peroxidise or to reduce. He did not think that he had any remarks to make with regard to the observations that fell from Prof. Forbes. One point, however, he thought he ought to mention before concluding, and that was that the rate of discharge with the lithanode elements could be varied within wide limits. He had been asked by Prof. Thompson whether he had ever discharged the plates at an extremely low rate. He really could not say that he had done so. He had almost invariably had in his mind the necessity of discharging them with some degree of rapidity, but still with a degree of rapidity which did not involve a large expenditure in platinum. According to the conductivity of the plate—according to the quantity of platinum employed in establishing the contact, so would the rate of discharge vary within wide limits. He had not been able to take in more than a small percentage of the observations that had been made, but he should be surprised to have it brought home to him that either the storage capacity or the rate of discharge of any secondary battery was higher than—or was even as high as—the capacity and the rate of discharge which had been stated to belong to the lithanode battery by Prof. Forbes that evening. He concluded by intimating that he might at some future time have occasion to refer to the rest of the discussion in the *Journal* of the Society.

[Mr. Swinburne has favoured us with a copy of the following communication which he has sent to the Society's *Journal*.]

I was sorry to be too ill to attend the discussion on Mr. FitzGerald's paper. If Mr. FitzGerald's lithanode is half as good as it looks, it is certainly the greatest advance in secondary batteries since the days of Planté. Many seem to have tried to make plates of peroxide of lead, so as to avoid local action, but they have not been commercially successful. The late Mr. Tribe started the idea, but his peroxide seems to have been too soft. The writer tried to make peroxide by electrolysis of an alkaline solution, but his peroxide, on the other hand, was too dense and impervious. Mr. FitzGerald seems to have solved the problem, and to have got over the chief fault; that is, if lithanode is itself durable. Mr FitzGerald does not say how he makes lithanode, but it is presumably a mixture of lead sulphate and peroxide, the sulphate being the binding material. If the lead sulphate is the only binding material it seems probable that it will be eventually turned into peroxide if the cell is overcharged, as in practice all cells are, when the plate will fall to pieces. The material must be either impervious or pervious, or it may be formed of pieces of impervious material with chinks and crannies so as to expose a large surface. Thus, if the particles were examined under the microscope one might expect to find lithanode made up of innumerable little lumps agglomerated together with interstices between, so that there is an enormous surface exposed. The material might thus be almost impervious, and the thin film being converted into peroxide would give the plate enough output. The peroxide made from alkaline solutions is almost impervious, but on discharging a very thin film of sulphate is formed. It seems, therefore, as if the peroxide must always be to some small extent pervious. The sulphate in the lithanode cannot be exposed to the acid at any points, for if it were it would be converted on charging or overcharging into peroxide. The sulphate must therefore always be protected by the peroxide, just as the lead in an ordinary plate is; the cementing material on which the whole life of the plate depends is therefore protected from the acid in just the same way as the lead is in an ordinary battery. It would thus seem that there is no reason to suppose that lithanode will last any longer than ordinary lead plate. This always assumes that lithanode is merely lead peroxide cemented together by lead sulphate, and I hope my reasoning or my premises may be wrong. There is, however, one fundamental difference, that is, that lithanode can only be injured by overcharging, while the prejudicial action in lead plates goes on practically always. Mr. FitzGerald's theory that the lower electromotive force is due to the formation of a sesquioxide of lead seems improbable. Some time ago I objected to this theory that even if such a compound can be formed, it cannot be formed in the presence of sulphuric acid.* It seems much more likely that the fall in electromotive force is due to the acid in the interstices being used up, so that there is only very weak acid or water available. Perhaps basic salts are formed. This would account for the fall in electromotive force if they were formed in one plate or both. The failure of cells is more often due to the reduced plate than is generally supposed. Before drawing any conclusions it is always advisable to test the plates with proof plates, as described in my paper a week or two ago. I would suggest that the experiment with the platinum plates, one having peroxide and the other peroxide and sulphate mixed, does not definitely prove anything. The sulphate may have merely insulated the peroxide in the plate. It also seems strange that such cells could give anything like two volts. Dr. Gladstone has to some extent misunderstood me. I certainly did not refer to him when I spoke of chemists forgetting their chemistry when working with electricity, as is evident from the context, more especially as it was Messrs. Gladstone and Tribe who brought people to their senses, and reminded them that lead oxides did not remain in the presence of sulphuric acid. Dr. Gladstone goes on to say, however, that to view lead sulphate as containing lead oxide was very antiquated chemistry. I do not think he can have understood the drift of what I said. The most modern chemists certainly often write such a compound of lead as the sulphate $PbOSO_3$, as if it were a compound of PbO and SO_3. Though Dr. Gladstone may not write $PbOSO_3$, surely he writes the reaction as if the peroxide and the spongy lead were first converted into lead oxide, and the lead oxide were then acted on by the acid to form sulphate with the elimination of water. What I tried to show was that if such an action took place, the only energy available as electrical energy would be that due to the algebraical sum of the energies of the formation of lead oxide; but energy equal to that due to the formation of lead sulphate from lead oxide would be converted into heat, and would not be available in the outer circuit. If the lead and lead peroxide were converted into PbO, and a secondary action with the electrolyte then took place, one would expect to get the same electromotive force from lead cells whatever the electrolyte. Of course I am aware that the energy of combination does not fully account for the electromotive force of cells, and it seems probable that there are what might be called Peltier effects of enormous magnitude. For instance, if water is decomposed, with platinum plates, and also with a zinc cathode and peroxide anode, the electromotive forces required are very different, while the chemical and physical changes are the same in each case. Dr. Gladstone lays stress on the value of lead sulphate, as it prevents local action in a cell while standing, and points out that its formation is therefore necessary to the life of the cell, but he does not say that the high electromotive force of a sulphuric acid lead cell is due to the strong affinities of the electrolyte and coatings. Mr. Preece mentions that he has tried sodium carbonate to remove lead sulphate, as proposed by Mr. Barber Starkey. It surely would be better not to wait till a lot of sulphate is formed and then reduce it, but to put a little sodium sulphate, not carbonate, in the cell at first to prevent the accumulation of sulphate, as proposed in my paper. It cannot be a good plan to put much sodium sulphate in a cell, as creeping may result.

REGULATIONS FOR ELECTRIC LIGHTING IN THE PARIS THEATRES.

The following is the full text of the regulations recently issued by the Prefect of Police with regard to the employment of the electric light in theatres and other public buildings in Paris:—

Preliminary Formalities.

Article 1.—Any one wishing to install the electric light in any theatre, café, concert room, or other public place under our authorisation, must make a declaration to the Prefect of Police. It will be necessary to

* *Electrician*, July 10th, 1885.

support the application with (1) a detailed plan (three copies), showing the situation of the dynamos, boilers, and of the steam engines, gas or air engines, the batteries or accumulators, and the various conductors. (2) A note describing these various machines, their horse-power, the power to be expended in arc lamps, or in incandescent lamps, and the number and intensity of each of the latter. (3) A sample of each of the wires or cables employed for this lighting, three metres at least in length.

Article 2.—The work may not be commenced until after the administration shall have granted permission for the execution of the plan, as proposed, without alteration.

Article 3.—After completion the installation shall not be brought into use until a further permission has been obtained, and the commission will be required to witness a preliminary trial.

Article 4.—No modification shall at any time be made in the installation without going through the same formalities.

Boilers, Engines and Chimneys.

Article 5.—The steam engine, gas, or air engines, which drive the dynamo machines and the furnaces of the steam engines, must not be placed in any part of the building accessible to the public or to the general *employés*.

Article 6.—The furnaces and fuel must be placed in separate chambers built of some completely incombustible material, provided with iron doors, and separated from all other parts of the building by substantial masonry, or by partitions of iron. These chambers must be properly ventilated, either by air shafts, or by mechanical means, so that the temperature shall never rise above 40°.

Article 7.—The installation of the boilers is to conform in all respects to the regulations of the public administration already in force.

Article 8.—The chimneys are to be built of brick, of such thickness and section as may be required for the size of the furnaces to which they belong. They must always be carried to a height of 5 metres above all other chimneys within a radius of 200 metres. These chimneys are to be placed outside the main buildings, in the courts or yards attached, unless special permission is obtained to the contrary from the Commission Supérieure of theatres.

Batteries, Accumulators, and Dynamo Machines.

Article 9.—The batteries and accumulators are to be placed in an apartment specially well ventilated, and in all cases where injurious vapours are given off they are to be enclosed within a special casing connected with air shafts opening above the roofs. All acids and other chemical products intended for their maintenance are to be kept under lock and key, and are never to be accessible to the other *employes* of the establishment.

Article 10.—The dynamo electric machines are to be fixed in a dry place not containing any easily inflammable material. They are to be mounted upon insulated foundations, and the space around them is at all times to be kept clear of all objects which might cause any accident to the persons in charge of the machines. The machines are to be placed in the charge of a superintendent and of experienced workmen. The precautions which should be taken in view of their personal security are to be inscribed upon a tablet fixed in sight of the workmen.

Cables and Conductors.

Article 11.—All conductors in the machine room are to be firmly supported and conveniently arranged for inspection, and marked and numbered.

Article 12.—Commutators are to be constructed in such a manner that they are never liable to produce a permanent arc or dangerous heating. They are to be mounted upon slate, stone, or some other incombustible material.

Article 13.—The switch-board is to be furnished with a voltmeter and an ammeter for each circuit, and, if necessary, with regulating rheostats.

Article 14.—Both positive and negative conductors are to be provided with safety fuses made of a metal easily fusible, and which melts if the current becomes too great. Similar fuses are to be employed at all places where a larger wire is joined to a smaller one, so proportioned that they will not allow too much current to pass. These cut-outs are to be fixed in such a manner as to be thoroughly protected from moisture.

Article 15.—Each part of the circuit must be so calculated that the diameter of the wire employed is proportionate to the current which will traverse it. The current is never to exceed two amperes per square millemetre of section.

Article 16.—The maximum electromotive force for alternating currents to be 120 volts; for continuous currents the difference of potential is not to exceed 300 volts at the terminals of the machines, or, if the source of current is exterior to the building, at the place where the cables enter.

Article 17.—When the source of current is exterior to the building the two cables are to be provided with an automatic interruptor which does not permit an electromotive force exceeding 300 volts to be established, also with a voltmeter and an ammeter. These apparatus are to be placed as near as possible to the point at which the cables enter the building.

Article 18.—Only metallic circuits are permitted. It is forbidden to employ the water or gas pipes, or any metallic part of the building to complete the circuit.

Article 19.—The wires are to be covered with an insulating material, and the insulation is not to be less than 300 megohms per kilometre.

Article 20.—All wires and cables are to be substantially fixed, and are at all points to be separated from one another by a distance of at least 10 millimetres for incandescent lights and 20 millimetres for arc lights. The wires are also to be separated from any metal used in the construction of the building by a space of 60 millimetres, except when the cable is lead covered.

Article 21.—When the wires rest upon insulated supports, or pass through the floors, ceilings, walls, or partitions, or when they cross one another, they are to be protected by a second metallic envelope (besides the lead).

Article 22.—All wires which come within reach of the *employés* of the establishment are to be placed under wooden casing.

Article 23.—If the source of current is outside the establishment, the electricity may not be introduced at more than a single point.

Lamps.

Article 24.—Uncovered lamps are prohibited.

Article 25.—Arc lamps must be protected by glass globes closed at the lower part, and surmounted by a chimney with a grating.

Article 26.—All parts of the lamps which may be touched with the hand are to be insulated. The globes are to be surrounded by a metallic network when their position is such that if broken their fragments might fall upon any one.

Article 27.—The suspension cables of the lamps are to be incombustible and independent of the conducting wires. The said wires are never in any case to be used for the suspension of the lamps.

Supplementary Lighting.

Article 28.—If the building was originally lit by gas, and if this mode of lighting is maintained in case of extinction of the electric light, the gas fittings are always to be maintained in proper condition, and at each monthly visit, in the presence of the sub-commission, a trial of the gas lighting shall be made. Manometers are to be placed at the points designated by the commission.

Article 29.—In those parts especially where gas is no longer in use the fittings are to be cut off from communication with the gas main.

Article 30.—In all these cases the lighting by the means of oil lamps already in force is to be maintained.

Article 31.—By special permission of the Commission Supérieure, the oil lamps may be replaced by incandescent lamps, each being fed from a special battery or accumulator. In this case the safety lamps ought to be of a different colour, so as to distinguish them from other lamps.

Article 32.—The theatres, cafés, concert rooms, and other public places already lit by the electric light, in which the installation does not conform to these regulations, are to be made to comply with them within a period of six months.

ELECTRIC LIGHTING ACT (1882) AMENDMENT BILL.

This Bill came before the House of Lords, in Committee, on Monday last.

The Earl of CAMPERDOWN (in the absence of Lord Houghton, who had given notice of several amendments) moved that the following clause should be inserted before Clause 1:—

"Notwithstanding anything in the Electric Lighting Act, 1882, no provisional order authorising the supply of electricity by any undertakers within the district of any local authority should be granted by the Board of Trade, except with the consent of such local authority, unless the Board of Trade, in any case in which the consent of such local authority is refused, are of opinion that, having regard to all the circumstances of the case, such consent ought to be dispensed with, and in such case they should make a special report stating the grounds on which they have dispensed with such consent."

He said that the object of that clause was to recognise the interests which local authorities had in such matters. As the law now stood, when a provisional order was sought by a company they did not necessarily apply for the consent of the local authority, but went direct to the Board of Trade. It was true the Board of Trade took the opinion of the local authority, and there were then ample means of stating objections. The change which was proposed was that in the first instance the company should go to the local authority and ask for their consent, and if that consent was refused the company had power to appeal to the Board of Trade against the decision of the local authority. The local authority would thus have a veto, which, however, the Board of Trade might override.

Lord THURLOW said he had no objection whatever to the new clause which had been proposed by the noble earl, as it was an accidental omission in the Bill.

Lord STANLEY of PRESTON said the Bill was similar to that of last year, and the Government were prepared to support it, provided this and similar amendments were accepted.

The insertion of the clause was then agreed to.

The Earl of CAMPERDOWN said he had an amendment on line 22 which raised a question of principle. The Bill proposed to give electric lighting companies a period of 42 years to enjoy the fruits of their enterprise, and at the expiration of that period any local authority was to be at liberty to purchase the undertaking upon the terms of paying the then market value of the goodwill of the undertaking. It appeared to him that this offered electric lighting companies a greater privilege than was necessary or desirable in the interests of the public. If, after the period of 42 years, local authorities had to pay for the goodwill of these undertakings, their purchase would become impossible. Not only would a monopoly be created, but it would be a perpetual monopoly, just as the terms on which gas and water undertakings could now be acquired were so exorbitant that their purchase was impossible. It would be quite sufficient to allow the company a monopoly of 42 years and then to pay for their plant, but not their goodwill.

Lord THURLOW regretted that he could not accept the amendment. The provision in the Bill was necessary for the encouragement of a new in-

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dustry, and he believed there were no other alternatives to it but either to allow companies privileges for a greater length of time or to charge higher rates in order to recoup themselves for their outlay. He felt bound to take the sense of the House on this amendment.

Viscount BURY wished to endorse what had fallen from the noble lord who had last spoken. The Act of 1882 had failed because the terms offered to the companies had not been sufficient to induce them to invest their capital. He was glad that a revulsion of public feeling had taken place on this matter, and that a longer term of years was now to be accorded to undertakers of electric lighting. He did not think it unjust that the companies should be paid for the value of their goodwill, and should therefore oppose the amendment. He hoped that the words proposed to be inserted by the noble lord opposite would not be agreed to. If the Government would undertake to introduce at some future time a satisfactory measure dealing with this subject he thought that the noble lord would do well to be content with such an assurance instead of pressing forward a Bill which could not get beyond that House during the present Session.

Lord BALFOUR did not think that the electric lighting companies could demand to be placed upon the same footing as the existing gas and water companies. In his opinion the electric lighting companies ought to be glad to get such a Bill as this without waiting for what they might deem to be a more perfect measure (hear).

Lord BRAMWELL trusted that their lordships would not agree to the amendment. What was the substance of this controversy? It was this—capitalists said that they would provide the necessary capital for carrying out electric schemes if the Legislature would give them time to obtain a reasonable amount of profit upon their undertaking, and that if such undertaking resulted in a profit instead of in a loss they were to receive compensation for the risk of loss they had run by being allowed to receive something like the reasonable value of their undertaking. The suggestion of the other side was that the capitalists were to run all the risk of loss, and that when their undertaking had become a success they were to receive, not its full market value, but merely—he would not say the old iron value—but the value of the plant less the amount of its depreciation. The result would be that, assuming the plant had to be renewed every ten years, when the fortieth year arrived the renewal of the plant would be scamped, and every effort would be made by the undertakers to lessen the value of that which was about to be taken from them by the local authorities. This policy of the local authorities was a dog-in-the-manger policy. They said:—"We shall not do it ourselves; and you shall do it only on the terms we are willing to grant." Their lordships should remember that those unreasonable capitalists who desired to make such a profit were bound down in such a way that the dividends were limited to 10 per cent., and that when new capital was required it could be raised only on certain stringent conditions. He asked their lordships to bear in mind that not one of the witnesses called before the committee said that 42 years would give time enough, and if it did it was open to the objection that it would prevent electric undertakers from doing their best towards the end of the term. He therefore asked their lordships to reject one of the most unreasonable provisions ever proposed.

Lord LINGEN said that he agreed with the noble lord who spoke last but one, that they were now dealing, not with a case of vested interests already created, but with one in which a new bargain was to be made in which the interests of all parties could be fairly and judiciously considered without reference to the past. The figures brought before the committee impressed him with the magnitude of the question. The decision to which their lordships might come was of very great importance to municipalities. As to municipalities coming forward as trading companies, it was to be observed that when those monopolies were created by consent, there was very little difficulty in the matter; but it complicated the case when the monopoly might be introduced without the consent of the local authority. That made the great difference between the case of towns and that of private persons who wished to have electric lighting introduced into their houses. It should be remembered that the local authorities had the interests of the community to consider.

Lord HERSCHELL said he was not able to follow his noble and learned friend in the view that municipalities, which represented the public, had not a right to make the best terms they could in the public interest when persons had to come to Parliament to get a monopoly.

Lord BRAMWELL: They have a perfect right to get the best possible bargain for the public.

Lord HERSCHELL observed that the public authorities were bound to take care that rights were not acquired by companies which would be injurious to the public. He agreed with the noble and learned lord that it would be mischievous to pass a measure in such terms as to prohibit the introduction of a system of lighting or of anything else which would be advantageous to the public. Hence they had to consider those two points—that on the one hand the municipalities should be able to make the best terms they could, and on the other that Parliament ought not to impose restrictions which would prevent the public from getting an advantage that large numbers of people desired. For his own part he should very much regret any legislation which might have the effect of interfering with the introduction of electric lighting in private houses by those who desired it. As to the question whether the terms of the Bill were sufficient or not to promote the object in view, he thought one circumstance had been somewhat left out of sight. There could be no doubt that a monopoly was practically given to gas and water companies, which were first in the field, and simply because there was not room for more than a limited number of gas and water pipes under the public streets; but with electric lighting that would not be the case, because the space that would be occupied by such a system would be so comparatively small as to obviate all difficulties in this respect [hear, hear]. He did not know whether under the Bill a municipality would be precluded from entering into competition with an electric lighting company for the term of 42 years.

Lord THURLOW: Not so.

Lord HERSCHELL said that in that case if the system of electric lighting turned out a success there would be no difficulty in giving the public a competing scheme if unreasonable terms were exacted by the company in existence. This might materially affect the view as to the terms which the promoters of a company would have a right to ask; it would strengthen their right to ask that the undertaking, when it was acquired, should be taken upon terms which would fairly recoup them for the risks they had incurred. His noble friend behind him had suggested a course which had been often taken in similar cases, and that was not merely to pay for the plant, machinery, and so on, but to take the average price of the shares for a number of years and the earnings for a number of years. That would seem to him to be a reasonable course. He believed that municipalities would be conciliated by some such proposal, much more than if the Bill was passed in its present form.

Lord RAYLEIGH said he objected to the omission of the words in question, and he did so, not in the interests of capitalists, but in those of the public. If the words were omitted it was clear that the terms then offered under the Bill would be insufficient to attract capital. There was a general desire to encourage and develop this movement, and it would be a mistake to impose too severe terms at the outset.

Lord GRIMTHORPE said the House of Commons disregarded the evidence of competent authorities which was brought forward on this subject, and they all knew that the result was that the Act of 1882 had proved to be a great failure. The Select Committee of last year did the same thing, and he found on looking over the evidence that every single engineer and financier of experience who was examined was distinctly of opinion that the Bill in the form in which the noble lord opposite had put it would be again a failure. As the matter stood they had to choose between the opinions and evidence of the most competent electrical engineers and scientific men, and that of a number of town clerks and aldermen, who, in 1882, practically deprived the kingdom of the advantages of the electric light by the terms for which they stipulated. A great deal had been said about monopoly; but the word was altogether inappropriate to the matter in hand, and the arguments founded upon it were incorrect. The point at issue simply was practically whether the property was to be sold for what it was worth, or the owners were to be obliged to sell it at at a loss [hear, hear]. As to gas and water companies, such an obligation as it was sought to impose in this case was never placed upon them, unless the practice had been very recently altered, and he saw no reason for imposing it on electric lighting companies. It seemed to him that if this important industry was not to be treated unfairly the amendment should be adopted.

Lord STANLEY of PRESTON was bound to say personally that he supported the amendment moved by his noble friend opposite, but there was a wide and an honest difference of opinion in many quarters with regard to it, and he should be sorry to prejudice in any way the action which any noble lord might wish to take in this matter. His noble friend behind him made a kind of appeal to him to say that the Government would bring in a Bill dealing with this subject. He did not think it would be honest on his part to give his noble friend such a pledge. He had already explained that it was owing to his having been prevented by circumstances from introducing any measure dealing with this question that he told the noble lord opposite that he thought it was advisable that he should proceed with this Bill, and that they should endeavour as far as they could to assist in passing it through the House. Therefore he thought the matter ought not to be postponed, but dealt with at the present time. The question, then, was whether the Bill would be of the use it was intended to be if this amendment were added to it. He could not help thinking that in this matter they ought to go step by step. He was bound to a certain extent by negotiations and arrangements which took place consequent upon the committee of last year, and standing as he did, therefore, in the position of having to deal with this matter, he was bound to say that he preferred the lesser amendment instead of taking the larger step. In some way or other the question of the goodwill might hereafter have to be considered, but he did not feel himself able to accept that at the present time, and consequently he must vote against the amendment of the noble lord.

Viscount CRANBROOK said his noble friend who had just addressed the House spoke for himself alone, and not on behalf of the Government. For his own part he saw no reason whatever why a public body should get for less money that for which any private person would have to pay a larger sum.

The Earl of CRAWFORD and BALCARRES was confident that no local authority would have done what had been done by the personal care and attention given to the extension of electric lighting by members of the companies. In regard to the alleged creation of a new monopoly, he held that there was no monopoly in gas, which had to compete against oil and candles, and electric lighting ought not to be put on any other footing than gas, because it would have to compete with gas, oil, and candles. No monopoly was asked for excepting that which the companies could create for themselves by the excellent quality of that which they supplied, and the moderate price they charged for it.

The Earl of GALLOWAY suggested the withdrawal of the amendment to the noble lord opposite, who must see that the feeling of the House was against him.

The Earl of CAMPERDOWN, in reply to questions which had been asked, said he held that it would be most unfair that a local authority should have the power to compete with an electric lighting company during the forty-two years for which a concession had been granted, and he did not believe that a local authority would have such a power under the Bill. If the Board of Trade granted a concession to the private company for forty-two years, he apprehended it would refuse a similar concession to any other company, or to a local authority for the same district. How could we know without trial that the provisions of the Bill would be prohibitory

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of electric lighting experiments under the new term of 42 years? On the question of goodwill he would assent to a compromise, if one could be arranged. He was prepared to pay the value of plant and other things mentioned in the Bill, with a percentage added on account of compulsory purchase. But he was anxious to exclude uncertain calculations and valuations of prospective profits, which would be due to the expansion of a town and not to the outlay of an electric lighting company.

Their lordships divided on the question that the words stand part of the clause, when the numbers were—

Contents	45
Non-contents	10
Majority	— 35

The Earl of CAMPERDOWN said that, after their lordships' decision, he did not think it necessary to proceed with the remaining amendments on the paper.

Lord HERSCHELL said he did not quite understand why the words about goodwill had been introduced. He should have thought that if the undertaking were purchased on the terms of paying the value of the undertaking that would have covered the whole thing.

Lord GRIMTHORPE and Lord BRAMWELL agreed with the words of the Bill.

The LORD CHANCELLOR said he thought the words were necessary.

The clause, as amended, was then agreed to.

The remaining clauses were then agreed to.

LEGAL INTELLIGENCE.

Cocks and others v. The Great Western Railway Company.

This was an adjourned motion for a writ of sequestration against the Great Western Railway Company for disobedience to an injunction restraining them from so working the machinery for the electric lighting of their Paddington terminus as to cause a nuisance to residents in the immediate vicinity. The injunction was granted on the 26th of July, 1886, but its operation was suspended until the 19th of October to enable the company to make alterations so as to remove the grounds of complaint. On the 12th of November the motion was made for sequestration, on the ground that the nuisance continued, and his lordship having heard the evidence on both sides, came to the conclusion that there had been a breach of the injunction; but upon the representation of the company that they had been making serious endeavours to deal with the nuisance, and that if further time were allowed they would find effectual means of doing away with it altogether, the motion stood over. The principal ground of complaint was the noise caused by the rapidly revolving dynamos, but the plaintiffs also complained of annoyance from smoke, steam, dirt, and vibration.

Mr. GIFFORD, Q.C., and Mr. RASHLEIGH, in support of the motion, did not say that the nuisance had not been mitigated, or that the company had not done their best to remove it, but they contended that, having regard to the power of the engines employed, no remedy was possible.

The ATTORNEY-GENERAL (with whom were Sir Horace Davey, Q.C., and Mr. R. S. Wright) submitted that before his lordship could act in a matter in which there was such an extraordinary conflict of testimony, he would have to be informed of the actual state of the facts, either by his own observation or by the report of some independent person.

Mr. Justice NORTH, in giving judgment, said it was beyond all dispute that considerable alterations had been made by the company, and that there had been a diminution of the nuisance. He had himself paid a visit to the works of the company and some of the houses which were alleged to be greatly affected by the noise, and had come to the conclusion that the plaintiffs' witnesses had exaggerated the nuisance. He was of opinion that at the present time no appreciable discomfort or nuisance was caused by carrying on the works for the electric lighting. He therefore refused the motion, but gave the plaintiffs their costs.

COMPANIES' MEETINGS & REPORTS.

German Union Telegraph and Trust Company (Limited).

The sixteenth ordinary general meeting of the shareholders of the German Union Telegraph and Trust Company (Limited) was held at the offices of the Company, Winchester House, 50, Old Broad-street, on the 21st inst., under the presidency of Sir James Anderson.

The SECRETARY (Mr. W. Payton) read the notice convening the meeting, and the minutes of the last meeting, which were confirmed by the present meeting, and signed by the Chairman as correct. The report of the Directors, which has appeared in *The Electrician*, was taken as read.

The CHAIRMAN: Gentlemen, I must say that I have never presided at a meeting where there was so little of an adverse character to refer to in any way. We have made £2,000 more this year than last, notwithstanding the fact that we have a very low tariff. We are therefore in possession of a property which at a minimum tariff is capable of earning an increasing revenue. That is a point which I am sure everyone connected with a telegraph company would like to see in relation to his own company. Another congratulatory feature is that the Berlin Company have actually £67,738 as reserve, in addition to £27,000 of capital unexpended, so that this company has really a sum of nearly £100,000 of reserve. Moreover, we have our cable lying in shallow water along its whole track, and in a neighbourhood which does not require the keeping of any of those expensive luxuries, or necessities, known as Cable Repairing Steamers. The cable is laid in the English Channel, and connects three of the greatest telegraphing people in the world, Germany, England, and America, and it lies in shallow water, where it is easily repairable by steamers that can be hired when required. That is a feature which no other submarine cable company possesses, and, indeed, I think that this property, so far as one can speak of submarine cable property, is the most secure of any in existence, and offers, in my opinion, as sound an investment as we shall ever see in submarine cables. I am happy to say that I have not anything to refer to in the way of breaks or accidents last year. We had not a single interruption. As I have said, we are telegraphing at a low tariff, consequent on the battle that is going on in connection with the Atlantic cables; but that appears to act in our favour, because we made £2,000 more last year than we made in 1885, and we have had that increase in a year which at least has been described as under the influence of commercial depression. With these remarks I will now move the following resolution:—"That the report and accounts for the year ended 31st December, 1886, submitted to this meeting be, and they are hereby, received and adopted; and that a dividend of 6s. 3d. per share be declared payable this day free of income-tax, making, with the previous distribution of 5s. 9d., a total dividend for the year of 12s., or at the rate of £6 per cent. per annum."

Mr. H. G. ERICHSEN seconded the motion.

The CHAIRMAN put the resolution in the usual way, and it was carried unanimously.

Mr. ERICHSEN: I have great pleasure in proposing "That Sir James Anderson be, and he is hereby, re-elected a Director of this Company."

Count OSCAR VON REICHENBACH seconded the motion, which was carried unanimously.

The CHAIRMAN: I am much obliged to you for your confidence. I can only say that I think we are fortunate in this Company in having one of the safest little things possible, and I have no doubt that by-and-bye the proprietors will see the shares standing higher in the market than they do now.

Mr. J. W. FULLER then proposed the following resolution:—"That Mr. Henry Dever be, and he is hereby, re-elected auditor to the Company for th current year with a remuneration of £25."

Mr. KENNETH ANDERSON seconded the motion, which was carried unanimously.

The CHAIRMAN having intimated that that closed the business of the meeting,

Mr. WELLS said: Gentlemen, before leaving I think we ought to pass a vote of thanks to the Chairman and Directors, for it is most satisfactory, as the Chairman observed, to see a dividend of 6 per cent. this time, but it is very unsatisfactory to notice the price of our shares in the market. It is really astonishing that the investing public overlook so desirable a security.

Mr. FULLER seconded the resolution, which was carried unanimously.

The CHAIRMAN: I am much obliged, and I hope we shall continue to go on as prosperously as at present. I see no reason why we should not.

The proceedings then terminated.

Montevidean and Brazilian Telegraph Company (Limited).

Dr. Cameron, M.P., presided yesterday at the offices, Tokenhouse-buildings, Moorgate-street, over the ordinary general meeting of the shareholders in this Company.

The report of the Directors for the year ended December 31 stated that the percentage of gross revenue receivable from the Western and Brazilian Company showed a gratifying increase, being £2,370, as compared with £1,529 in 1885. There had been a continuous improvement in the traffic since the end of March, and the revenue had been favourably affected by the higher rate of exchange which had prevailed, the average being 20⅝d. per milrei in 1886, as compared with 18¾d. per milrei in 1885. The Directors were glad to observe that, so far as could be judged from the published returns of the Western and Brazilian Telegraph Company, the improvement in the traffic appeared to be fully maintained during the current year. The balance to the credit of revenue account amounted to £1,180, which, after making the usual provision of £500 for redemption of debentures, would enable the Directors to recommend a dividend at the rate of one shilling and sixpence per share on the preference shares. This would absorb £623, leaving a balance of £57 to be carried forward to next account. No further progress had been made in the negotiations with the Western and Brazilian Telegraph Company referred to in previous reports.

On the motion of the CHAIRMAN, seconded by Lieut.-Colonel G. W. MACAULEY, the report was adopted.

The retiring Director, Sir Thomas Gore Browne, was re-elected, as was also the auditor, Mr. W. S. Ogle.

The proceedings then terminated.

Direct Spanish Telegraph Company (Limited).

Report of the Directors for the half year ended 31st December, 1886, to be presented to the general meeting of shareholders, to be held at Winchester House, Old Broad-street, E.C., on Monday, March 28th, at 12 o'clock:—

The accounts for the half year show, after providing for debenture interest, and for expenses in connection with the reduction of the company's capital, a balance to the credit of profit and loss of £3,991. 18s. 1d. Notwithstanding the reduction of tariff made at the Berlin Telegraph Conference of 1885, and which came into force on the 1st July, 1886, the

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traffic receipts show an increase of £230. 14s. 2d. as compared to the corresponding half year of 1885, and an increase of £320. 4s. 2d. as compared with the last half year. The new Bilbao cable and the Marseilles-Barcelona cable have continued in excellent working order throughout the half year. As notified to the shareholders by the circular of 31st December, 1886, the reduction of the Company's capital came into force on the 1st January last; the annexed balance-sheet is therefore based upon the capital as it originally stood. The capital as reduced is now quoted in the official Stock Exchange list. The Directors propose to put £3,900 of the balance of profit and loss to the reserve fund, which would then amount to £18,577. 9s. 7d., and to carry £94. 18s. 1d. to the next account; but as £15,000 has been taken from the reserve fund since the 1st January, to meet the payment of dividends and income-tax on preference shares for the five half years ended 31st December, 1886 (in accordance with the arrangements made for the reduction of capital), the actual amount that now stands to the credit of the reserve fund is £3,577. 9s. 7d. Mr. Edmund Etlinger and Mr. John Denison Pender are the Directors retiring by rotation, and, being eligible, offer themselves for re-election. The auditor, Mr. Herbert R. Duke, retires, and offers himself for re-election.

Electrical Power Storage Company (Limited).

Report of the Directors for the year ended December 31st last, to be presented to the shareholders at the sixth ordinary general meeting, on Thursday next, the 31st inst., at the Cannon-street Hotel, London, E.C., at 12:30 o'clock:—

The profit arrived at by the result of the working of the year and by certain interests becoming marketable is £35,937. 11s. 3d.; the balance of profit and loss of 1885 amounted to £22,412. 6s. 9d., which, being deducted from the above profit, leaves a balance of £13,525. 4s. 6d. to the credit of profit and loss, which the Directors propose to carry forward. The shareholders will doubtless consider that the result of the operations of the past year is eminently satisfactory. The business of the Company has increased, and a further great extension may be expected, if the Electric Lighting Act is amended, as proposed in the Bill now before the House of Lords. The works have during the year been fully engaged in the manufacture of accumulators and sundry electrical apparatus, and in addition to cells of the lighting type, motive power batteries for electric launches, torpedo, and tramcar purposes have been successfully constructed. The greater part of these are in use in England, and have been supplied principally through the medium of electrical lighting companies and firms, with all or whom the Company endeavours to maintain a friendly alliance. Few installations are now erected in which the Electrical Power Storage batteries do not play an important part. The motive power cells have been chiefly used in connection with electric launches. Among the notable incidents of the year 1886 are the channel trip of the electric boat "Volta" and the public trials of the submarine boat "Nautilus," in both of which this Company's accumulators were employed. The experience gained with these and other launches would indicate that electrical navigation must at an early date develop into a prominent industry. There is little doubt that in time the Admiralty will use electrical launches as part of the indispensable fittings of men-of-war, which are now, with few exceptions, being fitted throughout with apparatus which is suitable for charging accumulators. These might be used for regulating and supplying the light in the vessel while the launch is hanging on the davits, which plan has been successfully adopted in the case of the launch supplied to the steam yacht "Northumbria" for His Grace the Duke of Bedford. Many of Her Majesty's ships have been fitted with accumulators for working the light in conjunction with dynamos. More headway has, however, been made in this respect by the Danish and Italian Governments, more especially the latter, which was in a position to determine precisely the merits of storage batteries for ship use from the trial made with the cells placed on the "Giovanni Bausan" nearly three years ago. The experiments conducted during the past three and a-half years in train lighting have proved thoroughly successful, as the Railway Electrical Contractors (Limited) have received orders for largely extended business on the London, Brighton, and South Coast Railway and other of the leading lines, and in consequence have commissioned the Company to manufacture a considerable number of train lighting batteries. As regards foreign and colonial work, the Directors have to report that a large contract for 100 tons of accumulators, to be used in the extensive arrangement for central station lighting in Vienna, which the Imperial Continental Gas Association is undertaking, has been fulfilled. The German Edison Company also use the Company's batteries in connection with their lighting stations in Berlin. Many mills and warehouses on the Continent have adopted the batteries, and the trade houses through whom these were supplied express themselves highly satisfied with the results obtained. Several colonial Governments are using the Company's apparatus, and the users in the colonies are gradually becoming aware of the advantages of storage batteries. In the home trade a substantial increase in the demand for the several types of cells is anticipated during the current year, as it is now a recognised fact among engineers that no electric light installation is complete without storage batteries, and much attention is at last being given to the running of electrically propelled tramcars, which must increase the accumulator business in this direction. The Folkestone Exhibition lighting, which was entirely carried out by this Company, ran without the slightest interruption, giving great satisfaction to the authorities. Many City offices have been lighted, among which may be mentioned those of the North British and Mercantile Insurance Company, English Bank of Rio de Janeiro, Union Bank of Australia, London and Brazilian Bank, the Leathersellers' Company, also numerous private residences. The lighting of the Prudential Assurance Company's offices with a plant suitable for 2,000 lamps was successfully accomplished in June last. The staff is now busily engaged upon several new installations. The plant for temporary lighting of evening parties and balls has been increased to meet the demand for this class of lighting. In the United States the Electrical Accumulator Company (in whose success this Company is greatly interested), has, under the able management of its President, Mr. Theo. N. Vail, made rapid progress. An interesting account of its operations, taken from the *Electrical Review*, of New York, accompanies this report. In addition to Elwell-Parker (Limited) the Company has granted a license to manufacture under royalty, for certain specified purposes, to the Edison and Swan United Electric Light Company (Limited). The Directors have appointed Mr. Frank King, who has made a special study for several years past of secondary batteries and their use in central station lighting, to the post of superintending engineer. The retiring Directors are Sir Daniel Cooper, Bart., and Colonel Frederick George Steuart, who being eligible offer themselves for re-election. The auditors, Messrs Deloitte, Dever, Griffiths and Co., also offer themselves for re-election.

The report is accompanied by a balance-sheet and profit and loss account, showing clearly the position of the Company.

CITY NOTES.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of the Brazilian Submarine Telegraph Company for the week ended 18th inst. amounted to £3,782.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 18th March were £3,067, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended 15th March are £3,383, as compared with £2,931 in the corresponding period of 1886.

NOTICES OF REMOVAL.—The Great Northern Telegraph Company inform us that since March 22nd their offices have been removed to 3, St. Helens-place, Bishopsgate-street Within, E.C.—The Henley Telegraph Works Company (Limited), inform us that on the 24th inst. their offices were removed to 27, Martin's-lane, Cannon-street, E.C.

PARTNERSHIP.—We have received the following note from Messrs. Thompson and Ritchie:—"We beg to inform you that we have taken into partnership Mr. Robert Thorburn Turnbull, who has for some time been with us in the capacity of engineer, and that henceforth the name of the firm will be Thompson, Ritchie and Co."

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. March 23.		Business Done Week Ending March 23. Highest.	Lowest.	
Anglo-American	34½,	35½	35½	33½	
Do. Preferred	55½,	56½	56¾	53¾	
Do. Deferred	14,	15	15¼	12¾	
Brazilian Submarine	10⅝,	10⅞	10⅞	—	
Cuba	11½,	12	12	11¾	
Do. Preference	18,	19	—	—	
Direct Spanish	2¼,	2¾	2½	—	
Do. Preference	7,	8	7½	7½	
Direct United States Cable	8¾,	9	9	8 5-16	
Eastern Telegraph	10¾,	11	11	10⅝	
Do. 6 per Cent. Preference	13,	14	13¾	13¾	
Do. 5 per Cent. Debentures, 1899	104,	107	106	—	
Eastern Extension	11⅞,	12⅛	12 1-16	11¾	
German Union	8¾,	9¼	9¼	—	
Globe Telegraph and Trust	5⅛,	5⅜	5⅜	5 1-16	
Do. Preference	12¾,	12⅞	12⅞	12 1-16	
Great Northern	13¾,	14	13 11-16	13⅝	
Indo-European	34½,	35½	—	—	
Reuter's	6¾,	7¼	—	—	
Submarine	185,	195	—	—	
West India and Panama	⅝,	⅞	—	—	
Do. 1st Preference	9¼,	9¾	9¾	9½	
Western Brazilian	7½,	7¾	7 15-16	7⅝	xd.
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—	
Do. 6 per Cent. Sterling Bonds	100,	102	—	—	

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	⅝	—	—	
Oriental	3-16,	5-16	—	—	
United Telephone	12,	12½	12½	12	

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	—	—	
Do. (fully paid)	3¾,	4¼	—	—	
Swan	1⅜,	1⅝	1 9-16	1⅝	
Maxim Weston	3-16,	5-16	¼	—	xd

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37	36	xd
India Rubber, Gutta Percha, and Telegraph Works	22,	23	23	22½	

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NOTES.

JAPAN.—The telegraph system of Japan now comprises about 270 offices, connected by 6,855 miles of line, and 15,926 miles of wire.

SUBMARINE CABLES.—The cable of the Paris and New York Company has now been repaired.—The direct route to Bolivia, Chili, the Argentine Republic, and Uruguay, has been interrupted by a fault in the cable between Chorillos and Mollendo.

THE ELECTRIC LIGHT FOR EATON HALL.—We understand that Eaton Hall, Chester, is to be permanently lighted by electricity. The necessary works are being carried out under the direction of Mr. William Massey, of Twyford, the Duke of Westminster's consulting engineer.

"BRAY."—A correspondent in another column makes a suggestion of great value, which will, we think, be found to entirely obviate the difficulty which has led the Commissioners of Bray to abandon their proposed electric tramway. We see no reason why the scheme should not prove entirely successful.

ELECTRIC LIGHT IN THE U. S. NAVY.—It is a singular fact that up till quite recently the whole of the electric lighting plant in use in the U. S. Navy had been imported from France. The department is now building several fine steel cruisers, and these will be the first in the navy to be lit by American contractors.

DAMAGE BY LIGHTNING AT OSSETT.—A thunderstorm of unusual severity, especially at this season of the year, passed over a portion of Yorkshire on Monday last. At Ossett the church of Holy Trinity was struck by lightning, and the south-western porch was set on fire, but the flames were extinguished before much damage had been done.

PROJECTED TELEPHONE LINE FROM PARIS TO MARSEILLES. According to the Paris *E'venement* it has been decided to proceed at once with the construction of a special telephone line between Paris and Marseilles. The cost is estimated at about £35,000. It is intended at a later date to extend the line to Nice, Monte Carlo, and the Riviera.

OVERHEAD WIRES.—We recently referred to a proposal which has been made in America for solving the wire difficulty by erecting very tall poles (or towers) at the street corners, and stringing all wires one over the other in a single vertical plane. The suggestion has, of course, no chance of being taken seriously in this country, but it is stated that the City of New Orleans is about to adopt the system.

OVERHEAD WIRE ACCIDENT.—At Southport, on the 28th inst., while some men were repairing a telephone wire crossing a street, by some mischance the wire was allowed to fall to the ground. In so doing it looped around the neck of a cab-man, dragging him off his seat, and landing him in the street. Happily, however, no serious harm was done, and the man drove off apparently not much the worse for the adventure.

ELECTRIC RAILWAYS IN RUSSIA.—According to the Moscow *Technik* a project has been set on foot by some Belgian capitalists for the construction of a short railway in Russia to be worked by electricity, and to connect the towns of Varsovie, Wilanow, Mokotow, and Czerniakow. The necessary concessions have already been applied for; if they are granted this will be the first introduction of electric railways in the Russian Empire.

THE "KAPUNDA."—The unfortunate vessel "Kapunda," which foundered on February 1st off the coast of Brazil, after collision with the "Ada Melmore," carried a large quantity of iron telegraph poles and other material belonging to Messrs. Latimer Clark, Muirhead and Co. (Limited), of London. The material was on its way to Western Australia, to be used for a line of telegraph in course of construction by this company in that colony.

ELECTRIC TRAMWAYS IN THE STATES.—Twelve months ago a length of two miles and a-half of tramway in the town of Montgomery, U.S., commenced running by electricity on the Van Depoele system. This system employs overhead conductors, very similar to those of the Siemens electric railways. So complete has been the success attained that the tramway company has now decided to equip the whole length of its lines for electrical working.

THE UNITED STATES GOVERNMENT AND THE BELL PATENTS. The United States Government began its suit against the Bell Telephone Company, in the Circuit Court, at Boston, on March 14th, before Judge Colt. The suit is to annul two patents held by A. G. Bell, on the ground that he was not the original inventor, and that the patents were fraudulently obtained. The defence moved to be allowed to demur and plead at the same session. The sitting was adjourned pending the decision of the judge upon this point.

A TELLING JOKE.—It is perfectly well understood that no civilised country which entertains a proper sentiment of self-respect can afford to be without at least one original inventor of the telephone; but hitherto the Swiss have not been able to see their way clear to establish a satisfactory claim. According to *La Nation* the difficulty has, however, been solved by a proposal recently made in the Federal Council to the effect that in all State establishments the instrument should henceforth be called the "Guillaume Tel-ephon."

THE TAUNTON INSTALLATION.—On March 25th a deputation of citizens from Bristol and Bath visited the electric lighting installation at Taunton. The party were met upon their arrival by the Mayor and borough officers, and proceeded to inspect the installation, including the Castle Hotel, which is supplied by accumulators charged from the central station, and St. James's Church, which is lit with arc lamps, as well as the extensive street and shop lighting which has now been in successful operation for over twelve months.

FIRE.—The laboratory of Dr. Muirhead, of Cowley-street, Westminster, with his valuable collection of electrical instruments, had a narrow escape from being destroyed by fire last Saturday morning. Happily the fire broke out between eight and nine o'clock, when assistance in clearing out the greater part of the electrical apparatus and other articles of value was speedily obtained; but the part of the building in which the fire originated was practically gutted before the arrival of the fire brigade. The property, we believe, was fully insured.

THE TELEPHONE AND THE ELECTRIC LIGHT IN SWEDEN.—The use both of the telephone and of the electric light has made remarkably rapid progress in Sweden compared with other countries, the telephone being in use in many places, even in the farmhouses. The small town of Vexiö is now going to be lighted by electricity. The installation is to include six large lamps and 160 lamps of 16 candle-power for public lighting, and 500 lamps of about 10 candle-power for use in the houses. The tariff for the 10 candle-power lamps is at the rate of 2d. per hour..

FINSBURY TECHNICAL COLLEGE.—A meeting of the Old Students' Association was held on the 23rd March, at the college, when Mr. Bertram Chatterton read an exhaustive paper on "Hydraulic Motors." The discussion that followed was supported by Messrs. Humphreys, Webb, Pettigrew, A.

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Chatterton, and others. The chief interest appeared to centre in the advantages the lecturer had claimed for hydraulic motors over electrical motors, and it was agreed on all sides that while for extremely heavy work water power was unrivalled, it was quite out of the field for lighter work, requiring, say, only one or two horse-power.

GRAND TIMES FOR TELEGRAPH BOYS.—We learn that intense excitement reigns in the juvenile mind throughout the city of Washington. The offices of the Baltimore and Ohio Telegraph Company are besieged by boys of all classes eager to be appointed as messengers, and willing in many cases to forego all salary or emolument. This unusual anxiety on the part of the Washington boy to become a useful member of society arises from the fact that the telegraph company in question has imported from Australia a stud of ponies, on which the messengers are to be mounted. Relays of ponies are kept standing all day outside the company's offices, and the system seems so far to be giving satisfaction all round.

THE BURMESE TELEGRAPHS.—An Indian paper states that the telegraph line connecting Bangkok with Burmah has been working satisfactorily in spite of the difficult country through which it had to be taken. This line will shortly be duplicated by another, crossing the hills between Siam and Burmah at Myawadi, to the north of the present line. Another line is in course of construction, passing from the capitals down the east side of the coast of the gulf. The line connecting Bangkok with Saigon has for some time past been out of order and useless, as the insurgents in Cambodia pull down the wires and cut them up for bullets. The line running along the river to Chiengmai will, it is said, be of considerable benefit to the teak trade.

MERCURY CONNECTIONS FOR SECONDARY BATTERIES.—Writing on this subject to *L'Eléctricien*, M. Reynier, who has had some experience with mercury contacts for secondary batteries, says :—"Relating to the fears expressed as to the permanent efficiency of mercury contacts, I ought to say that these contacts have been in use at Marly since August, 1886, upon 'forming' circuits (in 'forming' plates for the Reynier battery). They have always acted well, while thousands of plates have been 'formed' through them, the electrolyte being sea-water, which is far more corrosive than ordinary acid. In fact, the perfect action of these contacts in such unfavourable conditions has decided M. Blanc to adopt this plan for general use with accumulators."

HYPNOTISING BY TELEPHONE.—According to the *Zeitschrift für Elektrotechnik*, a M. Jules Liégois has made some successful experiments of hypnotising by telephone. The first experiment was made upon M. Gordoilet, one of the editors of the *Courrier de Meurthe et Moselle*, through a line about 1,500 metres in length. M. Gordoilet was hypnostised by the distant operator within two or three minutes of placing the telephone to his ear. A lady was subsequently sent into a hypnotic sleep, and further experiments on various persons showed that there was no difficulty in producing all the ordinary hypnotic effects on a distant subject by means of the telephone. Some time ago we described a series of experiments of the same kind which were carried out in France.

ELECTRO-METALLURGY.—The Institution of Naval Architects commenced its sessional meetings for the present year yesterday in the Hall of the Society of Arts, the Earl of Ravensworth, president, occupying the chair. The president, in his opening address, after referring to the remarkable development of steam navigation during recent years, said that a new rival to steel was now presenting itself in the shape of aluminium, as manufactured by the electric process. This metal was particularly valuable as an alloy, producing a compound metal of enormous tensile strength, and one that was free from corrosion. The question was simply one of price, and, if that was satisfactorily met, the new metal would produce a revolution in naval engineering.

THE TRANSMISSION OF POWER.—In a description of a 250 horse-power dynamo built for use on the electric railroad at Montgomery, Alaska, which is worked on the system of Mr. Van Depoele, we read that the machine gives 500 volts and 450 amperes at 350 revolutions, and measures 9ft. in length by 7ft. in width, standing 4ft. 7in. high. The field-magnets (of which there are apparently four) measure 2ft. by 3ft. by 2ft. The armature is 28in. in diameter and 40in. in length, and contains 3lb. of wire per horse-power. The dynamo will supply current for fourteen 10 horse-power and four 20 horse-power motors. It is significant to note that the machine was intended to run at 500 revolutions, and the discovery that the work could be done at 350 was considered both surprising and satisfactory.

THE BRIGHTON PAVILION.—The vexed question of lighting the Brighton Pavilion, which has been the subject of interminable discussion and not a little parliamentary language (*un*-parliamentary it would have been called in earlier times) at the meetings of the Town Council, has at last been solved in a manner which we have no doubt will prove satisfactory to all concerned. The matter has been placed in the hands of the Brighton Electric Company, who will supply current for their central station. It is difficult to understand why this decision was not arrived at long before. The tender of the company is at the rate of ½d. per lamp hour. Last year the installation made 838,900 lamp hours, which would amount to £1,742. Last year the cost of the installation was estimated at something over £1,800, although only 6 per cent. was allowed for interest and depreciation.

COLLIERY LIGHTING.—A colliery near Newcastle, called the "Harrison and Woodburn," has for the past four months been lit with 30 incandescent lamps. The current is obtained from a Gramme machine, which is fixed at a point half way down the shaft. The lamps are placed 30 yards apart, and the furthest point reached is about 540 yards from the machine. The wiring is enclosed in wooden casing fixed to the sides of the galleries. Some of the lamps are provided with Mr. Miles Settle's device for securing the extinction of the light without the chance of sparking in the event of an accident to the lamp. This arrangement, as our readers will probably remember, consists of an outer globe containing water, in which the lamp bulb is set to float stem upward, thus making a contact which is broken immediately the water falls.

"SANITAS."—The use of the disinfectant termed "Sanitas" is so general throughout all telegraph stations situated in tropical climates, that we shall not be going out of our way if we mention that this company has recently introduced a new preparation which they call "Sanitas Air Purifier." It has been designed to effect, by simple exposure, the purification of the air of dwelling rooms, factories, state rooms and cabins on board ship, theatres, public halls, sick rooms, hospital wards, &c. The preparation consists of a fine wood-flour, impregnated with camphoric peroxide, which substance—in common with the other healthful principles generated in pine and eucalyptus forests—it gives off when exposed to the air. The method of using it consists in placing a quantity in a saucer or plate, and renewing about twice a week, or it may be strewed about the floors of buildings and court-yards to effect a similar pur pose by means of the fragrant vapours which are given off from it.

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A ROMANCE OF THE TELEPHONE.—An American paper tells the following story:—"A few days since Mrs. George Smithers, wife of an overseer, of Lowell, while shopping in that city, stepped into a store to telephone her husband in regard to some purchases. While the conversation was going on, another lady customer caught the name of Smithers, and seemed deeply interested. As soon as Mrs. Smithers left the store the lady called up Mr. Smithers, asked him a few questions, and the result was that he came to the store to see her. They were a long-severed brother and sister. Mr. Smithers has been in this country only about a year, whereas his sister left England fifteen years ago, when she married. Since that time she has been twice a widow, and Mr. Smithers had lost track of her entirely, not being aware of the name of her present husband. The lady was visiting some relatives of her husband in Centralville, and happened to be in the store at the same time as Mrs. Smithers."

THE LIGHTING OF LIBRARIES.—According to the *North German Gazette*, since the introduction of electric lighting (by arc lamps) into the library of the Technological School of Vienna it has been found that the covers of books bound in "boards" tend to turn yellow under the influence of the light. Prof. Wiesner has ascertained, however, that no injurious effect is produced upon bindings of leather. This conclusion would appear to be justified by the experience of the British Museum Library, where arc lights have now been in use for nearly five years, without, so far as we are aware, causing any such injury as is complained of at Vienna; but in the British Museum Library the greater part of the volumes are re-bound in leather. The *North German Gazette* draws the conclusion that gas is preferable to electric light for use in libraries, a conclusion which is opposed to all previous experience, and by no means warranted by the facts now set forth. The only legitimate conclusion is that incandescent lighting should be preferred to arcs.

THE POST OFFICE TELEPHONE SERVICE.—A deputation of members of Parliament, representing the Associated Chambers of Commerce, have waited upon the Postmaster-General, for the purpose of advocating a reduction of charges of the Post Office for telephonic communication. Mr. Raikes replied that there were great difficulties in regard to the reduction of charges for telephonic communication, owing to the larger expense incurred by the Government in using two wires, as against one wire used by private companies. He stated, however, that the matter should receive further consideration. The following has since been received from the Postmaster-General: "The Department is not in a position to perform the telephone service on the reduced terms suggested by the association, inasmuch as the system provided by the Department consists of double wire lines, so as to prevent the possibility of over-hearing by one renter of what is being said on another line by another renter, as is invariably the case when single wire lines are employed."

PARIS.—Arrangements are being made by the newly-founded *Compagnie Française d'eclairage electrique* to supply electric light from a central station in the Rue Drouot. The light is to be charged by measurement with the Cauderay counter, at the rate of 20 centimes per ampere-hour, an undertaking being given that "the light furnished shall never be less than 33 candles per ampere." Assuming that the E.M.F. is maintained at the value required by this stipulation, this tariff is at the rate of about 1d. per 16 candle-power lamp-hour. This method of charging by amperes and assuming the E.M.F. is not very satisfactory, however convenient it may be to the company. Each subscriber has also to pay a fixed charge of 4fr. per lamp per annum. The company replaces all lamps which burn out after the installation has incurred a rental amounting to 10fr. per lamp per annum. This seems a very fair arrangement. Lamps broken accidentally are charged 5fr. A further charge is made for rental of the meters, the amount varying from 2·5fr. per month for a 10-ampere meter, up to 11fr. for one measuring 100 amperes.

THE EARLY DAYS OF THE TELEGRAPH IN AMERICA.—A correspondent of the New York *Electrical Review* has sent to that journal the following extract from a New York paper, dated 7th April, 1845:—"The following extract from the orders of the Postmaster-General to Prof. Morse will fully explain the plan to be pursued in telegraphing hereafter:—'For the transmission of each despatch there shall be paid in advance, at the office from which it is sent by the applicant, one-quarter of one cent. for each telegraphic character or letter. Upon the reception of a despatch at either office, it shall be the duty of the officers to have the same translated in a fair handwriting, carefully enveloped and sealed, and the magnetic characters immediately destroyed, and to place the despatch in the hands of the penny post for delivery, who shall be entitled to receive the same compensation therefor as for the delivery of letters transmitted now by mail. It is further ordered that the said superintendent and assistants in no case communicate to, or permit to be seen by any person, the contents of any despatch except the individual or individuals to whom it may be addressed.'"

ARC LIGHT CARBONS.—An American paper contains the following:—"The manufacture of carbons for electric lights has become an important business. At a trial in Cleveland for alleged infringement of patent a witness testified that of 150,000 carbons burned daily in the United States, 100,000 are manufactured in Cleveland, where there are twenty furnaces. The carbons are made chiefly of the residuum of oil after it has been refined; but the deposit about natural gas wells is also coming into use. The material is ground to a powder, a little pitch is added, and the substance is then placed in moulds. These are packed in boxes, and the latter placed in a furnace, where they are subjected to the most intense heat. The capacity of an ordinary furnace is 45,000 carbons. Through the use of a movable furnace roof, the patent on which forms the subject of contention, two furnances are constructed side by side, and, while the carbons in one are being burned, the other is loaded with boxes of moulds. Under this system two men load a furnace in one day, the carbons are thoroughly burned in five days, and the cooling process continues only twenty-four hours."

A CHINA TELEGRAPH SHIP.—Preparations are being made to launch from the shipbuilding yard of Messrs. Doxford and Sons, Pallion, a splendidly modelled steel screw steamer, specially constructed for the China telegraph service, and also to act in the capacity of a naval cruiser if required. The vessel will be provided with all the necessary machinery for the laying down and the repairing of submarine cables, and in addition she will carry six large guns. Of these four are in the 'tween-decks, with specially constructed water-tight ports, and two long range six-inch Armstrong breech-loaders are to be placed on the upper deck. To accommodate the latter, which are to be arranged as bow and stern chasers, the windlass and steering gear are considerably modified, so that no hindrance to the fire will take place. The guns are to be mounted on cylinders 5ft. in diameter. The hull of the vessel is constructed of Siemens-Martin steel ⅝in. thick. The length of the vessel is 220ft., breadth of beam 32ft., depth of hold 20ft. She will be fitted with a set of triple expansion engines,

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constructed by Messrs. Doxford and Sons themselves, which will indicate 1,100 horse-power, and are calculated to drive the vessel at 13 knots per hour.

THE PARIS EXHIBITION OF 1889.—The terms agreed upon for the lighting of the Paris International Exhibition of 1889 by the syndicate of French electricians are of a somewhat singular character. The syndicate is to supply light to the extent of 250,000 candle-power, and the actual cost is estimated at from 2,500,000fr. to 3,000,000fr., depending in part upon the period during which the exhibition remains open, probably somewhere between 150 and 180 days. The consideration agreed upon is to take the shape of one-half share in the receipts for admission during the evening (at 2fr.), and the right to charge a tariff to the exhibitors in certain classes under a scale approved by the commissioners. Another clause provides, however, that as soon as a net profit of 500,000fr. has been made, the syndicate is to return one half of its subsequent gain to the commissioners. Upon the basis of the experience gained in the previous International Exhibition at Paris it is estimated that the receipts available for division will amount to between 6,000,000fr. and 7,500,000fr. The expenses are therefore expected to be at least fully covered from this source, leaving the charge to the exhibitors and extra receipts on special occasions as clear profit.

LIGHTHOUSE ILLUMINANTS.—Another bulky Blue Book on the subject of lighthouse illuminants has just been issued by the Board of Trade. It consists principally of correspondence which has taken place between the Department, the Trinity House, and various shipowners throughout the country. The actual value of electric light for lighthouse purposes is still a matter of dispute. The report of the Trinity House Committee, which investigated the whole subject two years ago, has not been accepted as final. The opposition is, doubtless, to some extent, factitious, arising from those whose interests are affected, while to some extent the complaints of pilots as to the dazzling effect of the beam may be well founded. The idea, however, which is still industriously promulgated that the electric light has less power than gas or oil of penetrating fog was thoroughly disproved by the experiments of the committee, who, it may be as well to repeat, summed up their report in the following terms:—"That the electric light, under all conditions of weather, is the most powerful, and has the greatest penetrative power in fog," and "That the Trinity House recommend mineral oil as the most suitable and economical illuminant for the ordinary necessities of lighthouse illumination, and that for important land falls, where very powerful light is required, electricity offers the greatest advantages."

A NEW STANDARD CELL.—M. Guoy describes in the *Comptes Rendus* a cell suitable for use as a standard of E.M.F., and which possesses some advantage over the Latimer-Clark cell in that its E.M.F. is as high as 1·39 volt, whilst the temperature correction is said to be only about ·0001 per degree C. The cell is practically equivalent to a Latimer-Clark, in which the sulphate of mercury has been replaced by the peroxide, HgO. The cell is made up with a layer of mercury at the bottom, in contact with a platinum wire sealed into the glass, a layer of oxide above the mercury, and sulphate of zinc on the top. The E.M.F. does not arrive at its final value until the cell has been made up for several days; but after this, when measured on open circuit, it is said to remain constant within ·001. Care should be taken to avoid agitating the cell unnecessarily, for, as in the Latimer-Clark, the E.M.F. is slightly affected by any disturbance of the mercury. The cell also polarises very strongly if a current is taken from it, but quickly recovers its normal condition on open circuit. The tendency to polarise when used for zero reading on the galvanometer—that is, with short contacts only—is said to be quite negligible. On the whole, it would appear from this description that the substitution of oxide for sulphate of mercury produces an element whose working qualities are about on a level with the Latimer-Clark, while it possesses the distinct advantages of a higher E.M.F. and a lower temperature correction. It is, however, a little early to decide finally on the merits of these cells, since M. Guoy has only studied their properties within the last three months.

THE DISTRIBUTION OF LIGHT.—Herr Herzberg furnishes the following information as a guide to the relation which should exist between the number of lights required to effect "a good and sensibly uniform illumination" of a given space, and the height at which the lamps are placed. In applying these figures it must, of course, be recollected that in general it is not our primary object to illuminate the floor, but a space probably some 3ft. higher, and the numbers in the first column should therefore be reduced in proportion. The following table applies to incandescent lamps of 16 candle-power; we give the figures in English measure, which accounts for their apparently arbitrary selection:—

Height of Lamp. Feet.	Space Illuminated. Square Feet.
6·5	86
8·3	75
9·8	67
11·5	64·5
13·2	62·5
14·8	60
18·0	58
20·0	56·5

For arc lamps the following data are given:—An arc of 800 candle-power may be taken to light from 13,000 to 17,000 square feet in the open air, but for large covered spaces, such as markets and railway stations, the limit will not exceed 5,500 to 6,500 square feet. For workshops and factories, lamps of about 500 candle-power are usually preferred, and for these about 1,700 square feet may be allowed.

BOULVIN'S SIMULTANEOUS TELEGRAPH AND TELEPHONE SYSTEM.—At the Brussels Telephone Exhibition M. R. Boulvin showed an arrangement by which a wire can be employed simultaneously both for telegraph and telephone service. There does not appear to be anything specially distinctive in M. Boulvin's system, except in the means by which he proposes to overcome the difficulties arising from induction from wire to wire. At present this effect causes a very serious difficulty in simultaneous working wherever the poles carry more than one wire. M. Boulvin's solution consists in the reduction of telegraph currents to about one-tenth of their present average amount, and in order to do this he uses a very delicate relay devised by M. Tommasi. This relay consists of a polarised needle acted upon by four electro-magnets, all of which tend to produce deflection in the same sense. With this instrument and a battery consisting only of a wire of zinc and one of copper dipped in pure water, it is stated that a message has been transmitted through a piece of dry wood 28cm. in length, and representing a resistance of 2½ megohms. With currents of this order it is certainly probable enough that the inductive disturbance of the telegraph on the telephone from wire to wire in a simultaneous system would become negligible; but, on the other hand, it is obvious that the relay has only a limited application in telegraphy. The fundamental objection to the general employment of any such system, therefore, still holds good, namely, that the interests of the telegraph which is at present, at any rate, by far the more important service of

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the two, would be sacrificed to that of the less important service of telephony.

DUBLIN.—In the very early days of electric lighting some arc lamps were installed at the offices of *Freeman's Journal* in Dublin. The result was by no means so satisfactory as had been anticipated; the sputtering and unsteadiness of the arc, and the bad colour of the light proved eminently unsuitable for a journalistic establishment, and before long the gas jets were relit. A year or two later a second attempt was made, this time with the incandescent light, and the beneficial results of the change from the heated and impure atmosphere of gas were fully appreciated. But, unhappily, an attempt had been made to run the dynamo off an engine already in use, and as no means were at that time available for governing the speed with sufficient nicety, the result was again unsatisfactory. After most of the lamps had been burnt out during one of the wild spins of the engine, electricity was once more abandoned for the time being. A third attempt was equally unlucky, but the mischief was on this occasion proved to have been due to the malice of an *employé*, who short-circuited the mains. This singular series of misfortunes has not, however, altered the determination of the *Freeman's Journal* to get rid of gas, and a trial installation, consisting of 22 incandescents and one arc lamp, is now in use, and at the end of two months will be increased to 200 lamps. As we have before had occasion to remark, whatever may have been the case at an earlier date, it is quite unnecessary to consider an isolated installation of electric light as in any sense an experimental undertaking. At the present time, in the hands of a competent firm, the work is carried out with just as much certainty of success as that of any other engineering operation. The present installation at *Freeman's* has been placed in the hands of Mr. C. C. MacCarthy, of Dundalk, one of the best known electrical engineers in Ireland.

AN AUTOMATIC MOON-WATCHER REQUIRED.—[N.B. This is a notice to electrical "inventors," and is not (in any other sense) to be understood as an advertisement for a lunatic, automatic or otherwise.] In order to explain what is meant by a "moon-watcher" we must premise that in many of the smaller towns both of this country and of the United States it is customary upon moonlight nights to do without any artificial light in the streets. A difficulty then arises owing to the impossibility of determining beforehand whether there will be moonlight at all, or, if so, how long it will last, even when, according to the almanacs, the full moon is really above the horizon. With gas and oil lamps the question of light or no light for the whole evening must be determined at dusk. But since electric lighting has penetrated into the villages of the States, the ease with which the lamps can at any moment be lit or put out has, according to the *Electrical World* of New York, given rise to the practice of keeping a man on the switch-board to dodge the moon in and out among the clouds. "Indeed," says our contemporary, "we know of a case where the attendant in an electric light station, not fifty miles from New York, can be seen every few minutes running toward the open window, bobbing out his head, and turning his glances heavenward, on a cloudy moonlight night. An unitiated observer, witnessing the performance lately, thought the man was afflicted with some strange mania, and on learning the true cause, felt much relieved at knowing that the sky-gazer was still in possession of all his faculties. As similar performances on the part of other electric-light men might lead to the spread of false impressions regarding their state of mind, we (*Electrical World*) are happy to announce that a means has been found for automatically showing the state of illumination outdoors, and the idea is due to a gas man." But the idea of the "gas man" seems to us extremely feeble. He proposes to have a radiometer exposed only to the moonlight, and to regulate the switches by reference to the speed of the rotation of the vanes. This proposal is, to say the least, far below the average level of practical Yankee ingenuity. Now, we ourselves have a far more practical idea, one which we feel sure will at once commend itself to the American imagination. Why not entrust the moon herself with the working of the main switches? SELENIUM—why, the very name of the element attests the value of the hint. Nothing can be easier.

PHOTOMETRY.—In experiments upon radiation, or photometry, the most convenient method of obtaining a secondary standard of comparison would undoubtedly be the burning of coal gas, if only we could rely upon a constant radiation for any length of time. To this end it would be necessary that the chemical composition of the gas burnt should remain the same throughout the experiment, and that the pressure should either be constant or at least capable of being accurately adjusted to a known degree from time to time. The first condition is probably fairly well attained in the gas supplied from public gasometers. But for the second condition it is necessary to have recourse to delicate means of regulation. In a paper in the *Comptes Rendus*, M. E. Branley describes some experiments which he has undertaken in order to find out what degree of accuracy may be obtained by this means. He employed a Vioche burner, which gave a flame 6cm. in height and 2·5cm. wide, using only the central part of the flame, through a rectangular opening 12mm. in height, and 18mm. wide, the centre of the slit being 28mm. from the base of the flame. The pressure was at first measured by a Kretz differential manometer; but by employing two manometers simultaneously it was found that their accuracy could not be relied upon within 1 per cent. Marey's drum manometer did not give much better results. M. Branley then constructed a manometer, which consists essentially of a box, with a corrugated metallic cover, like the case of an aneroid barometer, only upon a larger scale. This chamber opens into an india rubber reservoir, through which the gas passes, and changes of pressure, even when very minute and rapid, are at once indicated by the deflection of a beam of light reflected from a mirror, which is connected with the corrugated metal through delicate multiplying gear. This device was found to be at least 25 times as sensitive as the differential manometer. It will be understood that while no attempt is made to keep the pressure actually invariable, yet it is easy by the aid of the manometer and a special stop-cock to adjust the pressure to any fixed amount before each experiment, no matter after how long an interval. The radiation of the flame was then measured with a thermopile, readings being taken at intervals of half an hour. The following set of figures shows the constancy of radiation actually attained. Each interval represents one half-hour; the figures in larger type are placed at points when the manometer reading was purposely altered:—
... ; **123, 5**; 123, 7; 123, 7; ... ; ... ; 123, 5; 123, 7; 123, 4; 123, 4; ... ; ... ; 123, 6; 123, 7; 123, 7; ... ; ... ; **125, 6**; 125, 4; 125, 7; 125, 6; 125, 7; 125, 7; 125, 7; 125, 4; 125, 5; 125, 1; 125, 3; 125, 2; **124, 3**; 124, 7; 124, 5; 124, 1; 124; 124; 124, 2; 124, 2; 124, 4; 124, 2; 124, 5; 124, 1; 124, 4; **124, 6**; 124, 8; 124, 7; 124, 7; 124, 6; 124, 8; 124, 5; 124, 9. The variation in this table does not exceed 0·4 per cent. A similar table is given relating to some experiments with a moderator lamp, but, as might have been supposed, the results were not nearly as good, the variations sometimes amounting to nearly 2 per cent.

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SUBMARINE TELEGRAPHY.

The Congress on colonial, or better, perhaps, federal affairs, meets next week, and one of the subjects put forward prominently for consideration is that of "telegraphic communication." The subject naturally divides itself into two branches, dealing respectively with "internal telegraphs" and "external telegraphs." As in England, so in the various colonies, all questions relating to internal telegraphs have to be ultimately settled by the constituencies. The executive government can appeal to no other Cæsar, and can be condemned by no other judge. Unfortunately neither in the mother country nor in the colonies is the plain question of the business capacity of the "powers that be" decided by an appeal to the country; rather is business capacity overshadowed by an appeal to the passions, patriotism, or prejudice of the voters. However, our duty is not now to criticise the action of the omnipotent elector, but to point out that all questions relating to international telegraphic communication have to be decided by another tribunal, or somehow agreed to by several conflicting tribunals.

We have never heard, and, therefore, write subject to correction, that the English, French, German, Russian, or any of the Colonial Governments ever approached their co existing Governments with an initial scheme of international telegraphic communication. Nay, further, the pushing promoter, the developing company, have ever been the first to suggest such communication, and have oft-times been knocked from pillar to post for year after year before an unwilling consent was granted from the Governments for landing rights, or a moderate subsidy obtained. It was not such a very easy matter to get the necessary permission and the necessary capital for connecting the Continent with England, and we may be sure that under the prevailing ideas the concession to the Submarine Company will not be renewed. That may be the right thing to do, but surely no sane man would advocate the subsidising a new company to compete as an alternative route with the Submarine, yet this is very like what has been suggested in another part of the world for an alternative route to a colony which we may say already possesses duplicate routes, or, if routes be objected to, duplicate cables.

Men are too busy nowadays to read history, and many reason and argue as if telegraphic communication was as old as the hills. We may be dubbed heretics and called queer names if we say we can answer the question put by the Scripture writer, "Canst thou send lightnings, that they may go, and say unto thee, 'Here we are?'" in the affirmative. A writer in the early days of telegraphy said, "The lightnings have been trained to utter the language of men!"

It may be well, before discussing the present "business" position of telegraphy, once more to recall to mind and recount the various stages that have led from the primitive "halloo" to the latest scientific method of communicating at a distance.

The writer just quoted went on to say, "Can we conceive of anything more sublime or grand! more thrilling or lofty in the field of the imagination? We aspire in our arrogance to count the suns and planets within the visual range; explore the scope of the physical heavens; transfer light and revealed darkness to canvas; imitate the works of the Creator in senseless stone; compress air into dense and powerful bodies; generate a motive agency from water; follow comets and blazing heralds through trackless wastes; and knowledge and science in these pursuits have acquired immortal honours. But what is all this to subjugating the lightnings . . . the fearful omnipotence of the clouds, causing them in the fine agony of chained submission to do the offices of a common messenger—to whisper to the four corners of the earth the lordly behests of lordly man!"

History tells us the methods adopted for intercommunication in ancient days. Trumpeters upon hill tops, sentinels upon house tops, conveyed information by sound or by action along the selected route. Signal fires, again, were largely used in primitive times. Long before our own Macaulay wrote his "Armada," Æschylus gives a beautiful description of these visual telegraphs, of which we may be permitted to quote a couple of verses:—

> And it sent it on, the jocund sign,
> To Athos, mount of Jove divine,
> So that the might of the journeying light
> Skimmed o'er the back of the gleaming brine;
> Faster and farther speeds it on,
> Till the watch that keep Macistus' steep
> See it burst like a blazing sun!
> Doth Macistus sleep
> On his tower-clad steep?
>
> No! rapid and red doth the wild fire sweep;
> It flashes afar on the wayward stream
> Of the wild Euripus, the rushing beam!
> It rouses the light on Massapions' hight,
> And they feed its breath with the withered heath,
> But it may not stay,
> And away—away—
> It bounds in its freshning might.

The bugle, the signal fire, or the signalman could only transmit general information—preconceived information—such as the landing of an enemy, the successful battle, or the taking of a city. Fleet runners, horsemen, and carrier pigeons could of course convey special and private information, in contrast to the fires, &c., which of necessity were more or less seen and understood by all.

Passing from these ancient methods, which, however, were by no means despicable, we come to the scheme of the brothers Chappe. Here we had a systematic attempt to transmit messages. A signal post with arms formed the main part of the apparatus; the position of the arms depicted the letter to be transmitted. The system was largely used. The first message this telegraph conveyed to Paris was the announcement of the surrender of Condé to the Republic. Subsequently the English Government were offered electrical systems, but they had adopted that of Chappe, and were so averse to change that they would not hear of its supercession.

We have a reason for referring briefly to these ancient methods of telegraphy, and it is to show that in all cases where the transmission of information was carried out by these methods it was done at the expense of the State, and, up to the time of Chappe, absolutely for political—or, perhaps we ought to say, executive—purposes. The apparatus of the brothers Chappe was introduced at the expense of the various States, and was employed by the Governments first, the private telegrapher taking second place.

With the introduction of telegraphy by means of electrical apparatus a total change took place. The lines were—at any rate so far as England is concerned—constructed by private enterprise, as a means of investing capital profitably, and purely for commercial purposes. Political and stragetical questions did not enter into the heads of the telegraphic pioneers, though probably they were far-sighted enough to discern that the Government must employ their lines, and by so doing increase their receipts. Subsequently the whole system passed into the hands of the nation.

The submarine cable system has grown up, like the land telegraph system grew up, under the management of private companies. Capital has been subscribed for investment, and the business has been conducted under the ordinary commercial rules, the main object of course being to return a fair dividend to the investor of capital. Of late years there has been developing a persistent antagonism in some quarters to commercial rules being applied to cables. The investor is told he does not know how to conduct his business, and suggestions are promulgated which, if carried out, would ruin him altogether. We think that many people who interest themselves in the subject do not sufficiently grasp the conditions under which cable telegraphy developed and is carried on; and if they think about the matter, their conclusion will perhaps become more consistent and more in accordance with those of business men. We have in this article formulated our text, which we hope to dilate upon at greater length in a future issue.

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NOTE ON THE CALORIFIC EQUIVALENTS OF PROF. SILVANUS THOMPSON.

BY DESMOND G. FITZ-GERALD.

I have received a written communication and several inquiries in relation to some of the figures quoted by Prof. Silvanus Thompson in his very interesting contribution to the discussion upon my paper on "Reversible Lead Batteries." I confess I was for a moment puzzled when I found (at the end of p. 443 in the last issue of *The Electrician*) 85,400 calories given as the calorific equivalent of the energy of chemical affinity between Zn and sulphuric acid radical; the corresponding value given for copper being 37,520 calories. The matter, however, was cleared up when I noticed that the next figures (46,000) are almost exactly twice the value of the calories corresponding to the gram equivalent of electricity (96,600 coulombs) falling through a difference of potential of one volt, or, in other words, corresponding to 27 ampere-hours under unit E.M.F. Prof. Thompson has taken gram *atomic weight* values in lieu of the gram equivalent weight values which have hitherto been universally adopted amongst chemical physicists and electro-chemists, or, should I say, amongst old-fashioned electro-chemists.

But we do not feel quite at home with the values given by Prof. Thompson, even when they are halved. To pretend to accuracy in such values within one per cent. would perhaps, in our present stage, be affectation. But if, at any time within the last fifteen years, I had been asked to give a maximum value for the heat developed by the combination of gram equivalents of Zn and SO_4, I should have given 53,419 calories; and my minimum value would be 52,917. The calculated value of Favre and Silbermann (taking the equivalent of Zn as 32·45) is 52,838 calories. By the combustion in oxygen of the gram equivalent of Zn, Andrews obtained 42,282, and Dulong 42,185 calories; whilst Andrews found that the solution of the gram equivalent of ZnO in H_2SO_4 generated 10,455 calories. Thus the experimental values of Andrews and of Dulong for the $ZnSO_4$ equivalent would be 52,737 and 52,630. But the (halved) value given by Prof. Thompson is only 42,700 calories. If this be correct, we have in this direction something to unlearn as well as to learn.

Again, Prof. Thompson's value for the heat generated by the combination of gram equivalents of Cu and SO_4 would also appear to be much too low. Halving his figures (since Cu, as well as Zn, is dyad) we have 18,760 calories. But this value, according to Andrews, should be 26,872 calories; and Dulong obtained 20,096 calories by the combustion of the gram equivalent in oxygen; to which number should be added 7,720 calories generated by the solution of the gram equivalent of CuO in H_2SO_4.

The old values, it will be observed, give to the Daniell cell an E.M.F. somewhat higher (over 1·12 volt), and Prof. Thompson's values an E.M.F. somewhat lower (1·04 volt), than that which is generally accepted.

I am not acquainted with the work of Jscheltzow in connection with the determination of calorific equivalents; and I should be glad to be referred to any published account of it. But I must frankly admit that I have not been prepossessed in favour of this authority by the formulæ and thermal equivalents put forward by Prof. Thompson, and by the suggestion made by a contemporary of *The Electrician* that a formula, "practically my own," gives ·96 volt as the E M F. of a $Pb + 2H_2SO_4 + PbO_2$ couple.

The first four formulæ are to me more or less unintelligible; the last one is completely so. I can only vaguely perceive that the views and data of those who could adopt any one of these formulæ must be very much opposed to my own. I hold it as indubitable that the maximum energy and the maximum E.M.F. possible, with a given positive element and a given acid or saline electrolyte in contact with it, is expressed by the calorific equivalent of this positive combining with the acid radical of the electrolyte. Thus, if we take 52,900 as the calorific equivalent of Zn/SO_4, this calorific equivalent represents the maximum energy that can be developed by 27 ampere hours, and $\frac{52900}{23139} = 2·29$ volts represents the maximum E.M.F. under the given conditions. No chemical reaction occurring at the negative or cathode element of the couple can augment these values. But such a reaction—a combination—may diminish the expenditure of energy which in every voltaic cell (excepting those depolarised by free oxygen or chlorine) takes place at the cathode in effecting a chemical decomposition (reduction). In a lead peroxide cell, as in a chromic acid cell, the presence of sulphuric acid facilitates the liberation of oxygen; but no chemical combination affecting the PbO_2 can add to the energy or can augment the E.M.F. that would be developed by the combination of the positive element with the free radical SO_4. In practice—always excepting such cells as the Upward chlorine battery—this maximum E.M.F. is never attained; but in a lead peroxide cell it is, initially, very nearly attained, because a portion (one-fourth) of the oxygen in PbO_2 is very loosely held in combination—a fact which is perhaps not sufficiently borne in mind by those who consider that my asssumption as to the formation of sesquioxide of lead in the discharge of the cell is altogether gratuitous.

What I have said involves the somewhat bold assumption that the true calorific value of the gram equivalent of Pb, combining with SO_4 (free or nearly so), must be equal to at least 46,000 calories, corresponding to the E.M.F. of 2 volts. I am quite aware that this will be considered a very high figure, especially as the calorific equivalent of Pb, combining with (gaseous) O, is only about 27,670 calories. Nevertheless, I feel tolerably confident that the value which I arrived at many years ago for the calorific equivalent of Pb/SO_4, viz., 46,245 calories, will be approximately confirmed by other investigators.

It is to be observed that there are serious discrepancies between the electrical values calculated from the most carefully verified calorific equivalents, and the corresponding values based upon the electrical standards in use. And in some cases the question as to the side on which the error lies is one of practical interest, by reason of the simple and definite character of some of the calorific data. But, in general, these data are still too much open to question to allow of their use with any great degree of confidence in the calculation of electromotive forces, or in impugning the results obtained by the various committees on electrical standards.

[One or two of your readers, who may be representative of others, write to me saying that they cannot precisely see the relation between volts and calories. With your permission I will reply to them by a short elementary article in these columns.]

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXVIII.

BY OLIVER HEAVISIDE.

(Continued from page 391.)

Theory of the Christie as a Balance of Self and Mutual Electromagnetic Induction. Felici's Induction Balance.

As promised in the last section, I now give a simple, and, I believe, the very simplest, investigation of the conditions of balance when all six branches of the Christie have self and mutual induction. Referring to the same figure (in which we may ignore the extensions of branches 3 and 4 to Y_3 and Y_4), we see that as there are six branches there are twenty-one inductances, viz., six self and fifteen mutual. This looks formidable. But since there are only three independent currents possible there can really only be six independent inductances concerned, viz., three self and three mutual, each of which is a combination of those of the branches separately.

Thus, let C_1, C_3, and C_6 be the currents that are taken as independent, and let them exist in the three circuits AB_1B_2A, CB_2B_1C, and AB_2CA (*viâ* branch 6), with right-handed circulation when positive. Then the other three real currents C_2, C_4, and C_5 are given by

$$C_2 = C_6 - C_1, \qquad C_4 = C_6 - C_3, \qquad C_5 = C_1 - C_3;$$

if the positive direction be from left to right in sides 1, 2, 3,

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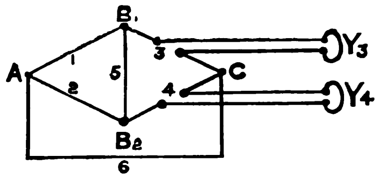
and 4, from right to left in 6, and down in 5, which harmonises with the positive directions of the cyclical currents C_1, C_3, and C_6,



Next, let m_1, m_3, m_6, and m_{13}, m_{36}, m_{61} be the inductances, self and mutual, of the three circuits. Thus, m_1 = induction through AB_1B_2A due to unit current in this circuit; and m_{13} = the induction through CB_2B_1C due to the same; &c. We have to find what relations must exist amongst the resistances and the inductances in order that there may be never any current in the bridge wire provided there be no impressed forces in 1, 2, 3, 4 or 5.

We obtain them by writing down the equations of E.M.F. in the two circuits AB_1B_2A and CB_2B_1C on the assumption that there is no current in the bridge wire, which requires $C_1 = C_3$; and this we do by equating the E.M.F. of induction in a circuit, or the rate of decrease of the induction through the circuit, to the E.M.F. supporting current, which is the sum of the products of the real currents into the resistances, taken round the circuit.

Thus,

$$\left.\begin{aligned} -p(m_1C_1 + m_{13}C_3 + m_{16}C_6) &= R_1C_1 - R_2(C_6 - C_1), \\ -p(m_3C_3 + m_{31}C_1 + m_{63}C_6) &= R_3C_3 - R_4(C_6 - C_3), \end{aligned}\right\} \quad (12c)$$

where p stands for d/dt. But $C_1 = C_3$, which, substituted, makes

$$\left.\begin{aligned} \{(R_1 + R_2) + (m_1 + m_{13})p\}C_1 &= (R_2 - m_{16}p)C_6, \\ \{(R_3 + R_4) + (m_3 + m_{13})p\}C_1 &= (R_4 - m_{36}p)C_6, \end{aligned}\right\} \quad (13c)$$

which have to be identically satisfied. Eliminate the currents by cross-multiplication, and then equate to zero separately the coefficients of the powers of p. This gives us

$$\left.\begin{aligned} R_1R_4 &= R_2R_3, \\ (m_1 + m_{13} + m_{16})R_4 - m_{36}R_1 &= (m_3 + m_{31} + m_{36})R_2 - m_{16}R_3, \\ (m_1 + m_{13})m_{36} &= (m_3 + m_{13})m_{16}, \end{aligned}\right\} (14c)$$

which are the conditions required. First the resistance balance; next the vanishing of integral extra-current due to putting on a steady impressed force in branch 6; and the third condition to wipe out all trace of current, and make branches 5 and 6 perfectly conjugate under all circumstances.

If the Christie consist of short wires, which are not nearly closed in themselves, then, as I pointed out before (*The Electrician*, April 30, 1886, p. 490), the theory of the balance expressed in terms of the self and mutual inductances of the different branches becomes meaningless, because the inductances themselves are meaningless. Under these circumstances, equations (14c) are *the* conditions of a balance, from which alone can accurate deductions be made. Even if we have the full equations in terms of the twenty-one inductances of the branches they will express no more than (14c) do. We could not, for instance, generally assume any one of the inductances to vanish, as it would produce an absurdity, viz., the consideration of the amount of induction passing through an open circuit. Hence it is quite possible that (14c) may be useful in certain experiments, in which such short wires are used that terminal connections become not insignificant.

At the same time it is to be remarked that such cases are quite exceptional. I would not think, for example, of measuring the inductance of a wire a few inches long, in which case (14c) would, at least in part, be applicable, if I could get a long wire and swamp the terminal connections. Still, however, equations (14c) and the way they are established are useful in another respect. In general I have not found any particular advantage in Maxwell's method of cycles. It has seemed to me to often lead to very roundabout ways of doing simple work, from what I have seen of it. This applies both when the steady distribution of current in a network of conductors is considered, due to steady impressed forces, as in the original application; and also when the branches are not treated as mere resistances, but transient states are considered, provided the branches be independent, so that, as I remarked before, the equation of a branch may be represented by $V = ZC$, where Z takes the place of R, the resistance in the elementary case. But in our present problem there is such a large number of inductances that there is a real advantage in using the above method, an advantage which is non-existent in a problem relating to steady states. We greatly simplify the preliminary work by reducing the number of inductances from 21 to 6. But, of course, on ultimate expansion of results we shall come to the same end.

If we use the first and third of (14c) in the second, it becomes

$$\left\{ m_1 + m_{31} + m_{61}\left(1 + \frac{R_1}{R_2}\right)\right\} \cdot \left(\frac{R_3}{R_1} - \frac{m_{63}}{m_{61}}\right) = 0 \; ; \quad . \quad (15c)$$

and, as either of these factors may vanish, we have in general two entirely distinct solutions. If the second factor vanish, the whole set of conditions may be written

$$\frac{R_1}{R_3} = \frac{R_2}{R_4} = \frac{m_{16}}{m_{36}} = \frac{m_1 + m_{13}}{m_3 + m_{13}}\,; \quad . \quad . \quad . \quad (16c)$$

whilst, if it be the first factor that vanishes we shall have

$$-\frac{R_1}{R_2} = -\frac{R_3}{R_4} = 1 + \frac{m_1 + m_{13}}{m_{61}} = 1 + \frac{m_3 + m_{13}}{m_{63}}, \quad . \quad . \quad . \quad (17c)$$

expressing the full conditions. Both (16c) and (17c) are included in (14c).

Suppose now that we make the branches long wires, or coils of wire, or many coils in sequence, &c., and can therefore localise inductances in and between the branches. We require to expand the six m's. Their full expressions will vary according to circumstances. When all the twenty-one inductances are counted, they are given by

$$\left.\begin{aligned} m_1 &= L_1 + L_5 + L_2 + 2(M_{15} - M_{25} - M_{12}), \\ m_3 &= L_3 + L_4 + L_5 + 2(M_{45} - M_{34} - M_{35}), \\ m_6 &= L_6 + L_2 + L_4 + 2(M_{62} + M_{64} + M_{34}), \\ m_{13} &= -L_5 + (M_{13} - M_{14} - M_{15} - M_{23} + M_{24} + M_{25} + M_{53} - M_{54}), \\ m_{16} &= -L_2 + (M_{12} + M_{14} + M_{16} - M_{24} - M_{26} + M_{52} + M_{54} + M_{56}), \\ m_{36} &= -L_4 + (M_{32} + M_{34} + M_{36} - M_{42} - M_{46} - M_{52} - M_{54} - M_{56}). \end{aligned}\right\} (18c)$$

Here L stands for the inductance of a branch, and M for the mutual inductance of two branches. These are got by inspection of the figure, with careful attention to the assumed positive directions of both the cyclical and the real currents.

In the use of these, for insertion in (14c), we shall of course equate to zero all negligible inductances. As an example of a very simple case, let coils be put in branches 4 and 6, between which there is mutual induction, and let the other four branches be double-wound or of negligible inductance. Then all except L_4, L_6, and M_{46} are zero, giving

$$m_1 = 0, \quad m_3 = L_4, \quad m_6 = L_4 + 2M_{64},$$
$$m_{13} = 0, \quad m_{16} = 0, \quad m_{36} = -L_4 - M_{46}.$$

Insert these in the second of (14c), and we get

$$R_1(L_4 + M_{46}) = -M_{46}R_2\,;$$

or,

$$-L_4 = (1 + R_2/R_1)M_{46} \quad . \quad . \quad . \quad . \quad (19c)$$

The third condition is nugatory. Hence (19c), with a resistance balance, but without the need of measuring R_3 (or, equivalently, R_4), gives us the ratio of the M of two coils to the L of one of them in terms of the ratio of two resistances.

As another example, let all the M's be zero except M_{12} and M_{34}, whilst all the L's are finite. We shall then have, besides the resistance balances, the two conditions

$$\left.\begin{aligned} 0 &= (L_1L_4 - L_2L_3) + (L_2 - L_1)M_{34} + (L_3 - L_4)M_{12} \\ 0 &= (L_1R_4 + L_4R_1 - L_2R_3 - L_3R_2) + (R_3 - R_4)M_{12} + (R_2 - R_1)M_{34} \end{aligned}\right\} \quad . \quad . \quad (20c)$$

If we now take $R_1 = R_2$, $L_1 = L_2$; that is, let sides 1 and 2 be equal, we reduce the three conditions (14c) to $R_3 = R_4$, $L_3 = L_4$. This is obvious enough in the absence of mutual induction; but we also see that induction between sides 1 and 2, and between 3 and 4, does not in the least interfere with the self-induction balance. Whilst remarkable, this property is of

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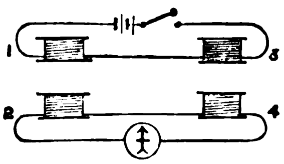
great utility. For it allows us to have the equal wires 1 and 2 close together, preferably twisted, and then this double wire may be doubled on itself, and the result wound on a bobbin. We ensure the equality of the wires at all times, doing away with the troublesome source of error arising from the disturbance of the resistance balance from temperature changes, which occur when 1 and 2 are separated, and also doing away with interferences from induction between 1 and 2 and the rest. We also do away with the necessity of keeping coils 3 and 4 widely separated from one another.

Passing to a connected matter, Maxwell, Vol. II., Art. 536, describes the well-known mutual induction balance with which Felici made such instructive experiments, that may be made the basis of the science of electromagnetic induction. It is very simple and obvious. The figure explains itself. If the M of the two circuits is *nil*, there is no current in the secondary on making or breaking the primary. This is secured when the M of coils 1 and 2 is cancelled by the M of coils 3 and 4, presuming that the pair 1, 2 is well-removed from the pair 3, 4.



The balance is independent of the self-inductions of the four coils, and also of the resistance of the two circuits, and may be made very sensitive. In fact, Felici's balance is unique, and should be used whenever possible. To exhibit its merits fully, we should use a telephone and automatic intermitter, giving a steady tone. It is then doubly unique, and it is difficult to imagine anything better. Compared with the galvanometer, the use of the telephone is a real pleasure. It is science made amusing.

But if we want not merely to balance M_{12} against M_{34}, but to know the value of M_{12}, of a *given* pair of coils, M_{34} should be both variable and known. They may be the coils of an inductometer (*Electrician*, Feb. 4, 1887, p. 282) calibrated once for all. There are many ways of doing it, in terms of the capacity of a condenser, or in terms of the inductance of a coil, &c., none of which methods have the merits of Felici's balance. Suppose it done by Maxwell's condenser method (using a telephone, of course). It is, perhaps, as good as any (certainly better than many) for the particular purpose, as we have only to give particular values to the time-constant of the condenser, a series of values with a common difference, and get silence at once by moving the pointer to a series of particular places, which is very different from dodging about to find the value of the time-constant when the M of the coils is fixed. We should also measure the L of each coil by itself, and it is well to previously adjust the coils to have equal L and R. But the present use of the inductometer is not to measure self-induction, but mutual induction. Therefore make 1 and 2 the coils whose M is wanted, 3 and 4 the coils of the inductometer. If within range (it is well to have inductometers of different sizes, for various purposes), we immediately measure M_{12}, and have the full advantages of Felici's balance.

But if there is metal about the coils 1 and 2 (of course there should be none, or very little) about the inductometer (or carefully divided), we cannot get telephone balances. If the departure from balance is serious, and it is not practicable to remove the metal, we may give up the telephone and use a suitable galvanometer, one whose needle will not move till all the current due to a make has passed, and then move if it can. But if the metal be iron, and we want to measure the steady M in presence of the iron (not finely divided), of course we must not remove the iron and measure something else than what we want to know. Then the galvanometer is indispensable. We lose the advantage of the telephone, but Felici's balance has still its peculiar merits left, in a very great measure.

Apart from the question of measurement, Felici's balance is highly instructive, as to which see Maxwell's treatise, to which we should add that the telephone should always be used if possible. Besides the experiments referred to, the balance is useful for studying the influence of iron in the field on the M of two coils, increasing or decreasing it, according to position. Use non-conducting iron (*The Electrician*, Feb. 11, 1887, p. 303). Here we have another proof to that there mentioned that there is no appreciable waste of energy in finely divided iron when the range of the magnetic force is moderate, although very *perfect* silences, like those when there are no F. currents, and no iron, are not always obtainable.

As regards Felici's balance when employed for observing differential effects, *e.g.*, Prof. Hughes's magical experiments with coins, and so forth, I cannot recommend it, for several reasons. The theory is complex, in the first place, so that scientific interpretation of results is difficult. Next, considerable accuracy in adjustment of the coils, in two equal pairs, similarly placed, is required. Lastly, the independence of resistance, &c., ceases when there are F. currents to disturb; and as we are not able to trace the variations of resistance, we may, in sensitive arrangements, when balancing one set of F. currents and reactions against another set, be interfered with by unknown temperature variations.

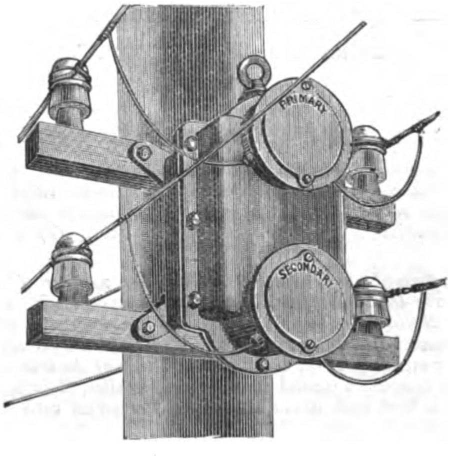
Perhaps the easiest way is to take a long wire, double it on itself and then double again, giving four equal wires. Wind two side by side to make one pair of coils (1 and 2), and the others in the same manner, to make the other pair. Of course we have increased sensitiveness by the closeness of the wires.

But it is far better not to use four coils, but only two, viz., coils 3 and 4 in the equal-sided *self*-induction balance, with 1 and 2 made permanently equal, as before described. The temperature error is then under constant observation, and we know at once when the resistance balance of coils 3 and 4 (apart from F. currents) is upset. Interpretation is also an easier matter, both in general reasoning and in calculations.

(To be continued.)

THE WESTINGHOUSE TRANSFORMER SYSTEM.

The Westinghouse Electric Company of the United States, who have acquired the Gaulard-Gibbs patents for transformers, are understood to have effected certain considerable modifications in the system as it has hitherto been worked in this country. The annexed cut represents the external appearance of one of the Westinghouse transformers. The distribution is



effected by means of overhead wires, the transformers being mounted upon the poles outside the building either in the streets or on the roofs. We see no reason why this arrangement should not work very well in America, although it is scarcely suited to the requirements of this country. The Westinghouse Company have already started some six or eight central stations on this system.

THE COWLES ELECTRIC FURNACE.—According to a Continental journal, during the process of smelting aluminum in the Cowles electric furnace, under certain conditions, rubies and sapphires of small size are formed in large numbers.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

SUBSCRIPTIONS.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

CONTENTS.

Notes ... 451
Submarine Telegraphy ... 455
Note on the Calorific Equivalents of Professor Silvanus Thompson. By Desmond G. FitzGerald ... 457
Electromagnetic Induction and its Propagation. By Oliver Heaviside. (Continued.) Illustrated ... 457
The Westinghouse Transformer System. Illustrated ... 459
ELECTRIC LIGHT LEGISLATION ... 460
Correspondence ... 461
Incandescent Lamp Manufacture.—XII. By J. Swinburne. 463
Applications of Electricity to Mining Operations. By F. J. Rowan, C.E. (Continued.) 464
The Evolution of an Ironclad Dynamo. (Continued.) Illus. 465
Switches and Ammeters. Illus. 467
Society of Telegraph-Engineers 468
Companies' Meetings—
Direct Spanish Telegraph Co. 470
Electrical Power Storage Co. 470
City Notes, &c. ... 472
Companies' Share List ... 472

GOOD FRIDAY NOTICE.

The next number of "The Electrician" will be published on THURSDAY, April 7th. Advertisements intended for this issue should be in the Publisher's hands not later than 4 o'clock on WEDNESDAY, April 6th.

ANSWERS TO CORRESPONDENTS.

F. GORDON.—(1) *Fuller's battery consists of a porus vessel containing a cylindrical rod of zinc, widened out at the lower end so as just to fit into the bottom of the vessel. Mercury is then poured in until the flattened base of the zinc rod is covered. By this means the zinc is maintained continuously in an amalgamated condition. Dilute sulphuric acid is poured over the mercury, and the outer jar contains a carbon plate in a solution of bichromate of potash and sulphuric acid.* (2) *Yes, glass jars will do.*

S.—(1) *In the formula referred to* N *signifies the number of lines of force which traverse the armature (in C.-G.-S. measure),* E *is the electromotive force developed in the coils,* n *the number of turns of wire upon the armature counted all round,* S *the speed in revolutions per second (not, in this case, per minute),* A *the cross sectional area of the iron core.* (2) *In coupling two compound wound machines in parallel, it is best to join up the circuits, so that each armature excites the series coils on the other machine.*

ELECTRIC LIGHT LEGISLATION.

In our last week's issue we published two accounts, immediately following each other, of attempts made to regulate by public enactment the status and working of the Electric Light, the one in Paris by order of the Commissioners of Police, the other in London by the authority of Parliament. We have so often complained of the exceptional legislation which hindered the development of electric lighting in this country that we lose no time in confessing that, at all events, as compared with the French metropolis, London has decidedly the advantage. Although the conditions under which electric lighting has been pushed forward here are not conducive to rapid progress, and although the discussion in the House of Lords on Lord THURLOW'S Bill betrays some of the narrowness which made its predecessor in 1882 a dead letter, yet there has not been, and is never likely to be, manifested in this country any such captious and panic stricken hostility to the new illuminant as that which has inspired the Regulations just promulgated for the protection of theatres and places of public entertainment lighted by electricity in Paris. M. HOSPITALIER says of the 32 Articles issued by the Paris Prefect of Police that they might have been summed up in a single clause prohibiting the electric light altogether.

We do not go quite the length of M. HOSPITALIER, for we confidently believe that the regulations will never be enforced, and that their very absurdity will expedite their withdrawal. Many of the purely technical restrictions will be abrogated, we imagine, without delay by the joint protest of French electrical engineers, and the merely obstructive clauses will vanish at the same time. Some of the regulations are, indeed, unexceptionable, and might well be adopted elsewhere. Others might fittingly be enforced by the insurance offices, but, according to our notions, are outside the province of the police. The Paris police, however, seem to take everybody under their special protection in a manner which we should resent as grandmotherly, and the document in question affords numerous examples of that character. We have not heard of any serious accidents in Paris due to the electric lighting of public buildings; but all the existing installations are commanded to conform to the new regulations within six months, under penalties. The engines, of whatever kind they be, are ordered into a separate building, shut off from the main edifice by stone walls or iron fireproof doors, and are to be inaccessible to the public or any of the general *employés*. Apparently it is feared that a French audience, or the attendants, may walk into the engine room between the acts in search of a new sensation, or for purposes of self-destruction. Not only is access to be impossible, but the temperature inside is never to rise above 40° C. As there are also restrictions with regard to the workmen's free handling of the wires and appliances, we may conjecture that the temperature is kept down to prevent the artisans catching cold when they go outside. Chimneys are to be of brick, and not only of regulation thickness, but 5 metres in height "above all other chimneys within a radius of 200 metres."

Proceeding in the same strain of solicitude, Article 9 requires that batteries and accumulators be placed in an apartment especially well ventilated; and "all acids and other chemical products" are to be kept under lock and key. One would imagine that fears were entertained lest some suicidal wanderer from the *foyer*, disappointed at finding the acid vapours carried off by "special shafts," might swallow the chemical products if not kept safely out of his reach. The audience are to be protected from falling glass by enclosing every lamp, incandescent as well as arc, with metallic network; and all parts of the lamp are to be "insulated." The installation itself is prescribed in the same unpractical spirit which finds expression in restrictions and injunctions that would do credit to a highly-fee'd gas engineer.

The British House of Lords, we are happy to observe, has completely shaken off the prejudices on which we have been commenting. There only remain some of the political sort, which came into being at the instigation of the Board of Trade when Mr. CHAMBERLAIN presided there. The Electric Lighting Act, which was passed during his administration in 1882, has been several times challenged to the bar of the

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Legislature, each time getting a fresh lease of the grave in which it was buried, because the mourners cannot agree about the terms on which it shall be disinterred. At every stage, however, these terms have improved, and in its amended form the Bill which has just received the approval of the Upper Chamber is superior to anything attempted before. Forty-two years are to be allowed for the electric lighting companies to carry on their business independently, their liability to compulsory purchase arising only at the expiration of that period. As it now stands, the Bill stipulates that the goodwill as well as the plant shall be purchased, if at all, at the market value. This is all that the companies have asked for, or nearly all; and at any rate it will suffice, if the Bill becomes law, to give life to their business on a footing which is workable and fair for all parties.

Of course there was the usual talk about the creation of monopolies; but this time it took tangible shape only to the extent of 10 non-contents, while the contents mustered four and a half times as many. Even the few dissentients, led by Earl CAMPERDOWN, were disposed to accept some compromise, having evidently been convinced that their former attitude regarding the plant, and their later attitude with regard to the goodwill, had become untenable. Not improbably a settlement in the House of Commons will be arrived at on the basis of compromise; but so long as the principle of payment for the business as a business is recognised, the companies will not stickle about the scale of computation. The House of Commons should be reminded of some excellent sense that was spoken when the House of Lords debated this question. Earl CRAWFORD AND BALCARRES pointed out that the much-feared monopoly did not exist even in the case of Gas Companies, seeing that they had had to compete with oil and candles, and now with electric light, which, in turn, would have to compete with all three. With reference to compulsory purchase by local authorities, Viscount CRANBROOK put the pertinent inquiry, Why should a public body get for less money that for which any private person would have to pay a larger sum? The answer was furnished in Lord BRAMWELL'S speech the same evening, when he described the local authorities as dogs in the manger, who would not do the lighting themselves, and would only let somebody else do it on terms of their own dictation. All the talk about monopolies is really at bottom prompted by the new-born zeal of local authorities to undertake public works which have hitherto been initiated and carried out by private capitalists. This may or may not be a praiseworthy ambition; but it has no right to be gratified except at its own expense and with all the hazards usually attending such undertakings. Like the Paris police, our local authorities want to secure the advantages of the business, but stipulate that its risks shall all be "insulated" or guarded by a "metallic network"—the metal to come out of other people's pockets.

CORRESPONDENCE.

MERCURY-CONTACTS AND CELLULOID IN SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the discussion on my recent paper Prof. Forbes referred to the use of mercury for connecting the plates, and asked for information in relation to the use of celluloid for mounting the plates and for rendering the cells watertight. I have to state that the method adopted for making the contacts by means of mercury was suggested by Mr. W. Kingsland, and that the use of celluloid (in lieu of vulcanite) was suggested by Mr. T. J. Jones, to whom the introduction of this material for battery work is entirely due. I may mention that the introduction of an amalgamated copper wire, at the bottom of the trough containing the mercury, is, in some cases, an improvement, particularly when the cells are liable to be tilted, as it allows the quantity of mercury to be reduced, whilst improving the conductivity. In regard to the celluloid, I at first thought it probable that the introduction of an oxidisable body, camphor, with the exciting fluid, might be prejudicial. But this does not appear to be the case; and, indeed, the behaviour of this body ($C_{10}H_{16}O$) may possibly prove to be of particular interest to Prof. Forbes, and also of practical importance. I am not in a position to enlarge upon this hint further than to say that camphoric acid ($H_2C_{10}H_{14}O_4$) would appear to be formed at the anode in charging; whilst a body isomeric with oil of turpentine ($C_{10}H_{16}$) is perhaps produced at the cathode.—Yours, &c.,
DESMOND G. FITZGERALD.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am obliged to Mr. FitzGerald for his answers to my queries, but I must confess I am still at a loss to thoroughly understand the meaning of "per lb. of Pb" as used in his table. Does Mr. FitzGerald mean that he has calculated out the capacity per lb. of lead, making allowance for the different amounts of oxide in the various cells, or that he has only made the allowance in the lithanode form, or how does he wish me to apply his figures to get at the actual values per lb. of plate in the cell?

In asking whether the plate was uniform after discharge, I assumed that the cell would be discharged at its normal rate with the usual amount of contact with the conductor allowed in the lithanode battery.

The bad conducting power does not affect the capacity "in the abstract." Perhaps not, but from the figures given it would seem to affect the capacity considerably in practice.

Mr. FitzGerald does not agree with the cause I gave for the diminution in E.M.F., but he gives no reason for his dissent. It seems to me that the acid accounts for the whole behaviour of the E.M.F. of secondary batteries. A cell when charged, unless left for some considerable time, when the acid is equalised by diffusion and local action, has in contact with its paste a small quantity of comparatively strong acid formed by the action of the current. This is soon exhausted, and we have a sudden drop of E.M.F. at commencement of discharge. While the action goes on at the surface of the plate the acid in contact with the paste is kept fairly uniform, and the E.M.F. is constant or drops very slowly, but when the paste near the surface is exhausted, and the inner paste is the active material, the E.M.F. drops rapidly, as the acid has to diffuse through the inert layers on the surface in order to replenish the acid absorbed by the action of the cell. The exhaustion of acid also accounts for the rapid recovery of E.M.F. on standing, and the fact that the capacity appears to vary with the rate of discharge.

Mr. FitzGerald states the capacity per lb. of lithanode at 16 ampere-hours at a potential not lower than 1·8 volt; further on he says the lithanode was discharged till its E.M.F. with spongy lead on open circuit was 1·8 volt (permanent). Was the spongy lead with which it gave 1·8 volt a fresh piece? Are all Mr. FitzGerald's capacities calculated from cells discharged till the permanent E.M.F. on open circuit is 1·8 volt? If so, can he tell us what is the final E.M.F. at the terminals of the cell when discharging at its normal rate?

Does not lithanode contain lead in a fine state of sub-division? If so, how is local action entirely eliminated?—Yours, &c.,

8, Wynne-road, Brixton, S.W. HERBERT W. BUTLER.

THE PELTIER EFFECT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: During the past term, in carrying out some researches with platinum wires, I noted effects which afterwards proved to arise from strain, and were considered of no importance and almost forgotten.

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Last week, however, you reported a paper by Mr. Shelford Bidwell, read before the Physical Society, in which the author claims the Peltier effect in a wire strained by its own weight to be the cause of a change of resistance when the direction of the current varied. Now, if this is so, the inverse must be true also, and such a wire must give a current when heated. As my experiments did give this effect, and so confirm Mr. Bidwell's opinion, I give them, as probably they may be of interest to some of your readers.

A piece of platinum wire, about No. 20, and 2ft. long, was bent into a loop and joined up to a galvanometer.

One end of it was then supported by a block of wood, and the other allowed to fall down the side without support, so that the central part sloped at an angle of about 45 degrees. On heating this part a current was produced which deflected the beam of light 20 divisions on the scale. When the wire was placed vertically the deflection was 40. The other end was next supported, and the slope of the wire of course became opposite, the current was inverted also, and to the same amount. This was evidently produced by the weight of the wire causing a strain, and was so interpreted by me at the time. It follows from Peltier's experiments that a current passing through such a wire would produce heat or cold according to direction, and hence increase or decrease the resistance of it, which is exactly what Mr. Bidwell gives in his paper.—Yours, &c., JAS. MONCKMAN, D.Sc.

Cavendish Laboratory, Cambridge.

ANODE AND CATHODE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: From your report (p. 445) of the recent meeting of the Society of Telegraph-Engineers I gather that the learned chairman had some fault to find with Faraday's terms "anode" and "cathode." It should be borne in mind, however, that a very common notion of "up" and "down" in Greek is that of putting to sea and coming to land. Probably the term "anode" was originally applied with the idea of that electrode being the one where the current puts to sea, *i.e.*, where it leaves the solid plate and takes to the watery element, the cathode in like manner signifying the landing place.

I should be much surprised to find that this mode of interpreting the two names was peculiar to myself, and that it is not based on some general authority.

A voltmeter is so far from being the first hand form of an electrolytic cell that I find it difficult to believe that the up and down course of the current in that arrangement is the origin of the distinctive names given to the electrodes.—Yours, &c.,

37, Burlington-road, W. E. ALDRED WILLIAMS.

TAUSSIG'S AUTOMATIC FIRE AND BURGLAR ALARM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read the description of the automatic fire and burglar alarm of Dr. Taussig, of Prague, in your number of the 25th inst. with very much interest, which was heightened by the curious fact that the whole description and the principles involved might have been taken bodily from my patent specification, No. 3414 of 1874, entitled, "Improvements in Automatic Fire and Burglar Alarms, applicable to dwellings and warehouses and in other places," in which a main line connecting numerous points is employed to convey automatic burglar and fire alarms, which are received and recorded on a self-starting embossing Morse recorder at a central station.

The thermostats or burglar alarm contacts are similarly placed in local circuits, and are operated, as described, by the rupture of the circuit.

We employ a rotating cam wheel to open and close the circuit in the same manner as Dr. Taussig's to produce the signal, and also the cam arrangement for cutting out the transmitting instrument when run down.

Our transmitting instrument is, however, operated by a spring instead of a weight, and we require no battery except that at the central station.

A modification of our system is in use for street fire alarm purposes over twenty-seven square miles in London, but the use of the Morse instrument, and the necessity for the interpretation of the marks on the paper of the Morse recorder have been abandoned for an improved receiver in which the name of the station signalling is pointed out on the dial.

Our fire and burglar alarm apparatus was shown in full operation at the Crystal Palace Exhibition of 1881-82, and received a gold medal, and also at the Exposition International d'Electricité at Paris in 1881, where it was also awarded a medal, and the buildings of the Inventions and Colonial Exhibitions were also protected by their agency.—Yours, &c.,

F. HIGGINS.

Exchange Telegraph Company's Offices, 17 and 18, Cornhill, E.C., 29th March, 1887.

LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I ask for an opinion on the above subject in your valuable paper? Would a house be considered efficiently protected from the effects of a flash of lightning if the conductor is constructed of inch iron pipe, properly erected, and with good earth?—Yours, &c., R. H. H.

March 29.

THE BRAY ELECTRIC TRAMWAY SCHEME—A SUGGESTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: How would it be to put a dummy horse, with moving legs, in front of the electric tramcars to quiet the nerves of the spirited animals driven by the local car owners? This might at any rate stop the "bray" of the donkeys there.—Yours, &c.,

A JOKER.

INCANDESCENT LAMP MANUFACTURE.—XII.

BY J. SWINBURNE.

Flashing. (Continued.)

An ohmeter may be used for flashing. This instrument consists of two coils arranged with their axes at an angle of about 60 deg. or 120 deg., and a needle at the point of intersection. One coil is wound with fine wire, and is in shunt to the carbon, while the other is wound with thick wire, and put in series with the carbon. The instrument is shown in Fig. 6. This

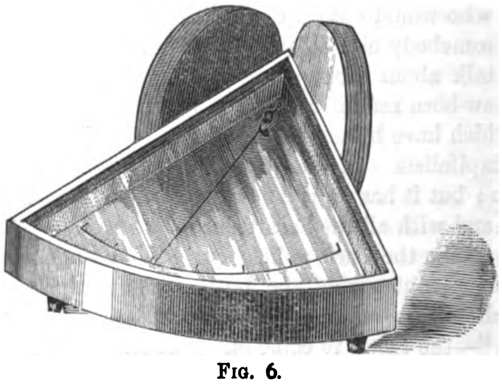

FIG. 6.

instrument has the axes of the coils at 120 deg., and the fields are arranged so that the total range would be 120 deg. if there were room for the needle to move. The series coil is preferably wound with two wires capable of taking about an ampere each. For high resistance lamps these are put in series, and for low in parallel. This allows both kinds to read on convenient parts of the scale. If the coils are designed so as to have small errors the instrument follows the same law as the skew tangent galvanometer, but it is best to calibrate it in its place by means of a resistance box. The chief fault in this instrument is that the fields being weak are interfered with by the earth's field, and by fields caused by neighbouring conductors. The earth's field does not cause errors in measuring electromotive force or current with a tangent galvanometer, but it does with an ohmeter, because it is wanted to compare

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the relative strengths of two fields, both of which may vary. A better instrument may be made by bringing the coils as close as possible to the needle, so that the field is as strong as possible; but a pivoted needle is then necessary.

The most accurate method of flashing is to mount the carbon as one branch of a Wheatstone bridge. Fig. 7 is a diagram or plan of the connections for a set of apparatus. The parts are shown lying on their sides like the houses in old maps. A is a flask for pressure flashing connected with the gas supply I, and with a waste pipe, J, going to the outer air. B is a vacuum flask connected with the 3-way tap D, so that it can be filled with gas from I, or exhausted by the pump G in the engine room connected to the exhaust pipe Y. H H are siphon vacuum gauges. C is an unexhausted lamp being finally flashed. K and L are secondary cells, which may be connected to a dynamo which is not shown. K is a batch of 10 cells connected to a switch 17 with 11 contacts, so that any number of cells may be used. L is a batch of 10 sets of 10 cells connected similarly in sets of 10 to the switch N. Any number of volts can then be had within one volt. For instance,

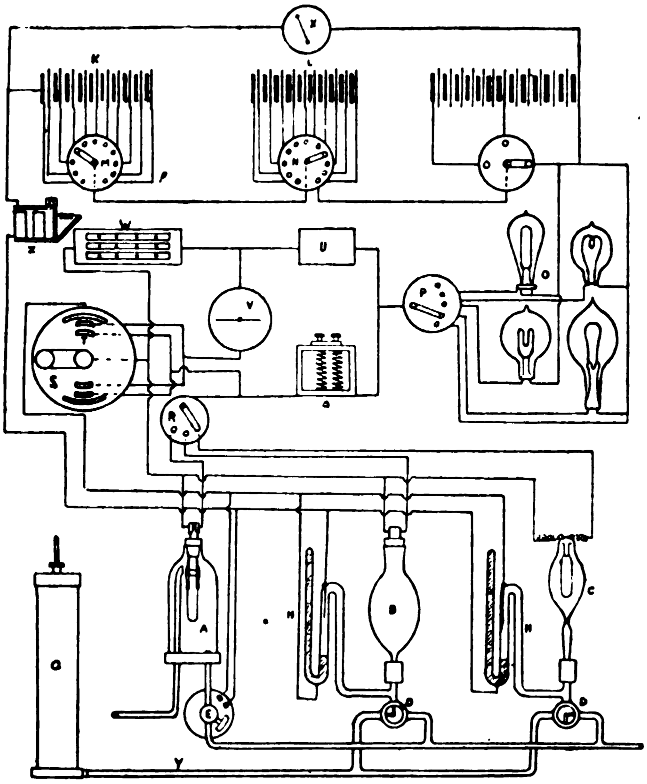

Fig. 7.

if 127 were wanted, and the cells gave two volts each, the switch N would be put on the seventh contact including 60 cells, and M would be made to include 3 or 4, giving thus 126 or 128 volts. Another batch of 100 cells should be available. A volt meter, X, tells what the actual electromotive force is. Following the circuit from L, O is a set of resistances, one being put in circuit by a switch, P. The resistance used first should be a little less than the resistance hot of the carbon before it is flashed. If the carbon is to be flashed down much it is as well to have another adjustable resistance also, which, when once set, can be put in and out by a switch. The circuit divides before coming to the resistance Q, which is one of the bridge resistances. It consists of two spirals of 20 ohms each, and these spirals can be arranged in parallel or series or singly, by the plugs on the top, so that the resistance is 10, 20, or 40 ohms. After joining one galvanometer wire the circuit is connected with A, B, or C. After passing through the carbon and meeting the wire from W, the circuit is led to the switch S. This switch is large and has renewable sparking pieces. The outer segments and the moving part are in the main circuit. The circuit is then led through the gauges H H, so as to be made only when there is a good enough vacuum, and returns to the cells with no gas. The tap E may also be connected to a safety switch to prevent flashing. The other side of the bridge U is made of two coils of 200 ohms each, which can be put in series or parallel, and the box W ranges up to 10,000 in hundreds and tens. These resistances are very troublesome, and are a frequent source of inaccuracy. If a carbon is being flashed with 200 volts at starting, it will have another resistance at O absorbing 200 volts more. If the carbon breaks, the full electromotive of 400 volts comes on the galvanometer V and the resistance W. If wire, especially iron wire, is used at O, this is enormously increased by the self-induction, especially if the coils of W themselves have self-induction. It is not always worth while to have 400 volts available, as it is expensive, but it is better. The galvanometer V is an ordinary detector, with stops to prevent the needles moving too far. Care should be taken not to reverse it. The galvanometer circuit is connected to two little contact pieces T on the flashing switch S. There is a little rubbing spring on the under side of the moving arm of the switch, which makes circuit through the galvanometer by touching both pieces. It is of course insulated from the arm. The object is that when the switch is put on the main circuit is made first, so that the carbon gets hot before the galvanometer circuit is made, otherwise the galvanometer would get a kick due to the high resistance of the cold carbon. A cut-out, Z, is placed in the main circuit to break circuit if the current is too large, as otherwise when a carbon breaks an arc is often formed across the clips, fusing the jaws together. The cut-out should work by a spring, so as to be prompt, and should be adjustable so as to suit all carbons, otherwise it is no safeguard. The switch S should be placed at one or other end of the system, otherwise the operators might get shocks. The switches of different operators should be at the same end.

Flashing should be carried on at as high a temperature as possible. If the temperature is too high there is a chance of breaking the carbon; but if too low the deposit is bad, and the carbon falls in resistance when the lamp is in use. The deposit should be bright grey, and as smooth as possible. The higher the temperature the harder and more durable the deposited carbon. Almost any gas that contains carbon will do for flashing; but coal gas is the most convenient generally. It may be enriched by being passed through benzol, but the advantage is little, if any. In fact, the slower the deposition is carried on the better, as it is then easier to measure the resistance accurately. The only way to ensure both slowness and a high temperature is to use either a gas which deposits very slowly, or a good vacuum, or both. Ether and alcohol vapour can be used with a vacuum. Of these ether is perhaps the best, but both are objectionable, as the fumes, especially those of ether, are unhealthy.

Carbons should be so proportioned as to need only a very small deposit of carbon to reduce them to the final resistance. When the deposit is thick the carbon is not so durable. A carbon made by thickly coating such a material as carbonised thread is quite weak, and does not last long. The deposited carbon does not really fill up the pores, as it is sometimes supposed to; it forms a coating on the outside, which is sometimes detachable, especially if the carbon is dusty. It is probably the want of homogeneity of the two kinds of carbon that makes a highly flashed lamp bad. If a carbon is flashed at a very low temperature, the carbon is deposited in little hairs or filaments which stick out all over the carbons. This sort of deposit is also sometimes due to the gas being too rich. In pressure flashing the carbon must only be lighted for a second at a time, otherwise soot is formed and deposited over the carbon and clips. The convection currents also keep the carbon cool in some parts. Convection currents are avoided to a great extent by the flask B, with a 3-way tap at the foot. When gas is admitted and continually drawn through, the carbons are apt to be flashed badly. When the draught is from the bottom and the pump is connected to the neck, the loop of the carbon is cooled, so that it is too bright in the finished lamp.

When flashing is done in the lamp itself great care must be taken not to flash with any air in the lamp, as it would be spoilt after all the work has been spent on it, and not to flash with a bad vacuum, which would blacken the glass. Such

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substances as carbon disulphide, chloroform, carbon tetrachloride may be used for flashing. The writer has tried those mentioned. The carbons were no better, and there were complaints of bad drains where the pumps were working. Chloroform is especially objectionable.

If carbons have been lying about a long time they will break when it is attempted to flash them. This is probably due to absorption of water, and can be avoided by baking the carbons in an oven before flashing, or otherwise heating them.

For very low resistance lamps for series lighting it is best to do most of the flashing under liquid.

Low resistance lamps demand some modifications, but there is no difficulty in making them. The carbons should be as thin as possible, otherwise a 16 candle-power lamp will be very short, as the surface of carbon must be the same as that of any other 16 candle-power lamp. If the carbons are short and thick a large proportion of the heat will be conducted to the joints, which will radiate it without giving out light. A tubular carbon is the worst form for low resistance lamps. The carbon should have as low specific resistance as possible. Generally unflashed carbon has not a low enough specific resistance to make lamps with thin carbons. Flashing, or, rather, deposition of carbon, to reduce the resistance is resorted to. The carbon is held vertically in a clip under a suitable liquid, such as benzol or alcohol. Methylated spirit is perhaps the most convenient and cleanest. The carbon must be held with the arch upwards, as it is softened at the high temperature necessary, and is dragged round by the vapour bubbles if held with the arch downwards. The current is increased quickly but gradually till the carbon is raised to a brilliant white, and the carbon is maintained at that temperture till the resistance is not much above that wanted for the finished carbon. It is afterwards flashed in the ordinary way to the final resistance after the final diameter has been carefully measured. The diameter is often considerably altered by the deposition of carbon on the surface, so that the final measurement of diameter must be taken after flashing. The chief source of error in low resistance lamps is the resistance of the joint between the platinum and the carbon, and the loss of heat by conduction from the carbon to the joint.

The writer, in conjunction with Mr. A. Wright, of Brighton, who has done a great deal in working out series house-to house lighting on a commercial footing, has introduced 3·3 ampere lamps working in batches of three on a 10-ampere arc light circuit. These lamps have to be made accurate both as to electromotive force and current. Mr. Bernstein is, however, the great apostle of low resistance lamps arranged in series circuits. There is, however, no great difficulty in making the lamps, but there is little demand for them yet, though it will most likely increase now.

The vessel which contains the methylated spirits should have a tin cover, which can be put on without removing the carbon and clip. The spirit cannot catch fire when the heated carbon is entirely immersed, but when it is violently boiling it sometimes does, and unless it can be readily extinguished a fire may be caused. The vessel is fixed down in the centre of a large tin tray, and a cover is arranged to fit over the whole apparatus, so that even if the spirit comes over the edge of the vessel into the tray and ignites, it can be at once extinguished by the operator. An exhausting fan can be arranged to draw off the vapour instead of letting it get into the room, as the fumes cannot be healthy.

APPLICATIONS OF ELECTRICITY TO MINING OPERATIONS.

BY F. J. ROWAN, C.E.

(Continued from page 440.)

VI. Comparison of Various Systems of Transmitting Power.

The writer purposed making a comparison as to cost and efficiency between electricity, steam, hydraulic power, compressed air, and wire rope transmission, but he found that so many engineers had already taken up this question that probably the most useful course he can pursue is to present extracts from some of the best of these comparisons.

Papers dealing very fully with the theoretical considerations involved in the various modes of transmitting power to a distance have been published by M. Arthur Achard, of Geneva, in *Proc.* Inst. Mech. Engineers for 1881, and by Prof. Reuleaux.

The advantages of compressed air as a distributor of power have been fully ventilated recently in connection with a scheme for supplying Birmingham with power in this way. It is said that a project is on foot to carry out this system in Berlin.

The following articles may also be consulted :—On Wire Rope Transmission for Pumping, *Jour.* I. and S. I., II., 1884, p. 622; The Cost of Haulage in Anthracite Collieries, *Jour.* I. and S. I., I., 1886, p. 282; Transmission of Power by Steam, *Jour.* Ibid, p. 283; and Hydraulic Pumping Machinery, *Proc.* Inst. C. E., Vol. LXXXIV., p. 513.

The papers by Prof. Schulz, A. Beringer, and Prof. John Perry, from which the following quotations are made, leave little to be added for the elements of a general comparison.

Prof. Schulz draws a very minute comparison between the cost and applicability of electric force on the one hand, and that of power derived from steam, compressed air, or hydraulic power on the other, for boring and cutting machines and underground hauling, pumping, and ventilating machines.

In the case of boring and cutting machines he takes the transmission of power to the face by electricity as about equal in cost to that of compressed air, and states that it may in some cases be rather cheaper; but when a plentiful supply and sufficient head of water are obtainable, hydraulic transmission is cheaper than either.

For distances of from 500 to 600 yards the useful effect of the electric transmission is about 50 per cent., against about 20 per cent. for that by compressed air, and to do the same amount of work the respective motive powers required are as 2 to 5. The electric system is proportionally the cheaper the greater the cost of fuel and the greater the distance to which the power must be transmitted.

Among underground locomotives the steam engine is the cheapest wherever it can be applied. The electric engine gives better results than those driven by compressed air; but the fireless locomotive invented by Moritz Honigmann, though not yet fairly tried, promises (according to Prof. Schulz) to give better results than either.

In the following table addition should be made for cost of extra ventilation to the results in the first two columns, as in these two cases two locomotives were at work :—

Underground Haulage by Locomotives.

—	Steam Engines. With Fire.		Steam Engines. Without Fire	Compressed Air Engines.		Electric Engines.
	Doman Mine.	Cessous Mine.	Honigmann's System.	Petan System.	Mekarski System.	Zaukeroda Coal Mine.
Cost of plant in £	1600	1600	550	650	1000	800
Interest and depreciation per mile ton in pence	·42	0·14	·50	·79	·81	·44
Cost of haulage per do. in pence	·60	0·51	·82	1·18	1·35	1·10
Total cost per do. in pence	1·02	0·65	1·32	1·97	2·16	1·54
Daily performance in mile tons	303	882	88	66	99	146
Length of run in yards	2530	5030	676	676	676	676
Time per run in minutes	2·3	3·3	1·5	1·5	1·5	2·6
Weight of machine in cwts.	86·3	156·3	47·2	53·1	45·2	31·4
	Ft. in.	Ft. in.			Ft. in.	Ft. in.
Height of machine	6 3½	6 10½	?	?	5 1	4 11
Breadth „	4 3	5 3	?	?	3 7¼	2 7½

When several electric locomotives are at work on the same line, the efficiency is considerably increased.

From the following table it appears that the electric system compares favourably with most of the others as regards cost. The "rope and counter rope" haulage system and those by endless chains are better adapted for moving very heavy weights. For subsidiary hauling engines, a comparison of cost between electricity and compressed air shows considerably in favour of the former; but hydraulic power, in cases where it can

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be applied, is cheaper still unless the water has to be carried for very long distances.

Examples of Different Systems of Haulage.

—	Rope and Tail Rope	Rope and Counter Rope.	Endless Ropes. With Great Speed	Endless Ropes. With Small Speed.		Endless Chain.		Electric Haulage for Comparison.
	St. Marie Pit, near Aniche.	Von der Heydt Pit, Saarbrücken.	Shire Oaks Pit in Nottinghamshire.	Bridge Pit in Nugau.	Meadow Pit near Wigan.	Barbach Drift, Saarbrücken.	Hasard Pit, Belgium.	Zaukeroda Pit.
			1.	2.	3.			
Cost of plant in £	1600	2300	750	2300	750	4000	5600	800
Interest and depreciation per mile ton in pence	1·36	·255	·29	·37	·39	·78	·22	·445
Cost of haulage per do. in pence	·52	1·01	1·80	3·65	2·00	·73	·22	1·09
Total cost per do. in pence	1·89	1·26	2·08	4·02	2·39	1·52	·44	1·54
Work done per shift in mile tons	96	720	203	500	148	436	1983	146
Hauling distance in yards......	600	4120	920	2170	640	1920	3500	676
Time per run in minutes	5·0	3·3	3·3	·6	·5	1·87	1·5	2·6
Duration of shift in hours......	10	10	12	12	12	10	8	16

1. The full tubs are drawn up an incline of 1 in 48.
2. ,, ,, ,, 1 in 62.
3. ,, ,, ,, 1 in 21.

Prof. Schulz publishes the following

Table of Electrical Installations.

Name of Pit.	Power of Motor.	Machine Driven.	Length of Lead.	Efficiency. Electrical.	Efficiency. Mechanical.	Efficiency. Total.
	H.P.		Metres.	Per Cent.	Per Cent.	Per Cent.
La Peronnière, near Rive-de-Gier	37·1	Hauling Machine	1500	50·0	37·0	30
Thibaut, near St. Etienne	5·0	...	250	45·0	38·0	25
Blanzy......................	17·	...	634	...	51·0 ?	30
Zaukeroda	14·7	Locomotive	893	46·6 ?	37·8 ?	30
Do.	5·0	Fan	780	50 0	26 0 ?	...
St. Claude, near Blanzy...	8·10	...	900	...	...	...

In spite of his previous remarks, Professor Schulz concluded that there is no field for electrical transmission in mining (special cases excepted), except for hauling on levels by locomotives, which could advantageously replace rope or cable haulage. It is not clear how he deduces the figures in his last column. The "hauling machine" at Blanzy is probably meant for the winding installation mentioned *ante*.

A very exhaustive comparison between electrical transmission of force and other mechanical methods in use was published in Berlin* in 1883, and awarded a prize by the Electro technical Society there. An excellent *resumé* of this paper, made by a French mining engineer, may be found in the *Revue Universelle des Mines, &c.*

The agents used for transmitting force which are here compared are—(1) Electricity; (2) Hydraulic pressure; (3) Compressed air; and (4) Tele-dynamic cables. The net cost of a unit of work in any given case is arrived at from the following elements :—

1st.—The cost of the power supplied by the prime mover;
2nd.—The useful effect of the system of transmission; and
3rd.—The cost of the erection and maintenance of the system.

As a basis of cost of power from the prime mover the following figures, given by Professor Grove at Hanover in 1876, are quoted, viz. :—

For (1) Small steam engines,	fr. 0·400	or about	4d.	per H.-P. per hour.
(2) Moderate sized engines,	0·280	,,	2¾d.	,,
(3) Large sized engines,	0 106	,,	1d.	,,
(4) Hydraulic engines,	0·008	,,	·076d.	,,
(5) Gas engines (gas at fr. 0·22 per cubic metre),	0 320	,,	3¼d.	,,

In arriving at the cost of transmission per effective horse-power by the various systems, only Nos. 3 and 4 of these prime motors are considered, and in all cases 14 per cent. is added to the cost of apparatus for interest and depreciation of plant.

(To be continued.)

* Kritische Vergliehung der Electrischen Kraftubertragung mit den gebræuchlisten mechanischen Uebertragungssystemen, par A Beringer; Berlin, J. Springer, 1883 *Resumé* by Ch. Arendt—*Rev. Univ.*, ser 2, tome 15, p. 522, &c.

THE EVOLUTION OF AN IRONCLAD DYNAMO.

(Continued from page 437.)

To reduce the resistance in the field of force was the next problem, and a great number of experiments were made with unipolar machines of different types. It was found that by an increase of the surfaces of the magnet ends, the resistance could be reduced. Fig. 4 represents a machine in which a tubular armature is rotated in an annular field. The hollow cylinder which surrounds the solid core was lengthened until a copper tube produced a current which deflected the galvanometer to the same extent as an iron tube. The machine is shown in longitudinal cross-section in Fig. 5, and Fig. 6 is an end view with the armature

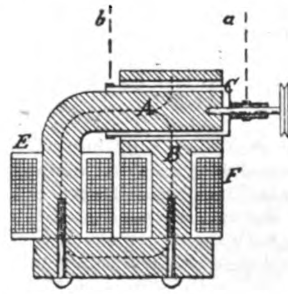


Fig. 5.

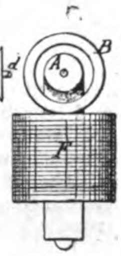
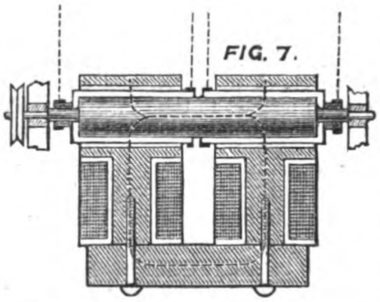


Fig. 6.

removed. A is the solid cylindrical end of the electro-magnet, and B the other end. The latter is a hollow cylinder which surrounds the core A concentrically, leaving an annular space between the two, which forms the field of force in which the armature is rotated. C is a tube mounted upon, but insulated from, the driving shaft *d*. Brushes to take off the current were placed at *a* and *b*. The solenoids E F served to excite the magnet.

After this model machine had been perfected two more machines (Figs. 7 and 8) of the same type were made. One had two fields of force, the other four; the electro-magnets were made of the same cross-section, the same quantity of insulated copper wire was used in each of the machines, and the same tubular armatures were used in each case. The result of a great number of experiments seemed to show conclusively that the magnetic circuit could be cut four times at least, and each cut produce a field of force equal in density to that when cut but once. The magnetic circuit in the first instance was longitudinally through the electro-magnet and the annular field of force where the [magnetic] current passed from face to face. In the second machine the [magnetic] current had to pass through air spaces twice and in the last one four times, and yet in each of the fields the armature produced the same current [E.M.F.]. When two or four armatures were used in the machines each of the armatures produced a current [E.M.F.] substantially equal to that produced by the armature in the first case.



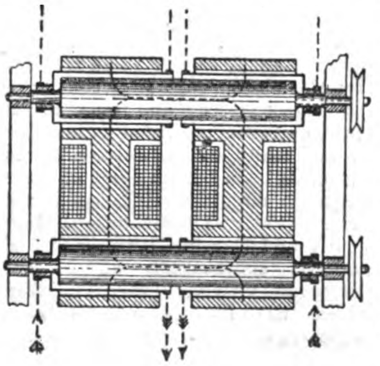


Fig. 8.

In the last machine four armatures were really excited by the same current and by the same helixes which had been used in the first machine, and the electric energy used in the first case to produce one field of force now furnished four. To test the same question in another way, a model of a bipolar machine with heavy iron armature cores and with four cheek pieces was made. The machine

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was constructed as in Figs 9 and 10. Two heavy rings of soft iron, A and B, were mounted upon a brass shaft, which had as bearings in two brass frames C and C' connected by bottom and top plates D and D' of brass. To the two plates four cheek pieces E F G and H were secured. Each ring had two cheek pieces, one above and one below, which closely fitted the rings. Each cheek piece covered about one-third of the armature, leaving about one-sixth on each side uncovered. Three copper rods *a a'* and *a''* were put in the grooves equi-distant from each other and close to the circumference of the rings. All three were connected on one side by a

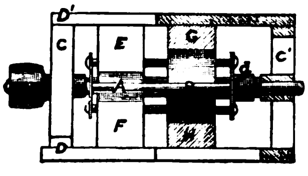


FIG. 9.

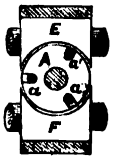


FIG. 10.

copper flange and on the other to three commutator plates at *d*, from which the current was taken by means of two brushes. An electro-magnet made of two bars of round iron with insulated wire wound upon them, and connected by cross bars (Fig. 11), were secured upon two of the cheeks E and F. The machine was then set in motion. The current [E.M.F.] produced caused a deflection of 30 deg. in a tangent galvanometer. Two bars of wrought iron of the same size and length were next bent in semi-circular form (as shown in Fig. 12), and wound with an equal quantity of wire; and the two horse-shoe magents thus obtained were put on the cheeks of the machine. One of the magnets connected the lower cheek F of the first armature ring with the upper cheek G of the armature ring B in the rear, while the other horse-shoe magnet connected the upper cheek E with the lower cheek H of the armature ring B in front.

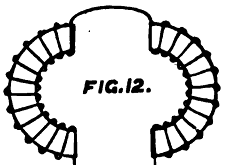


FIG. 12.

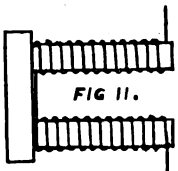


FIG 11.

The magnetic circuit thus obtained was as follows:—Suppose the magnetic current passed from cheek F into the armature A, through A to cheek E. It would then pass through the horse-shoe magnet which connects the cheek piece E with the cheek piece H and through the armature core B to the cheek piece G, then complete its circuit through the other electro-magnet to the cheek piece F. The cheek pieces F and H were of one denomination and the cheek pieces E and G of the opposite.

The machine as constructed had a magnetic circuit substantially like the unipolar machine illustrated in Fig. 6, in which the armature core A forms the crossbar for the armature core B and *vice versâ*. The armature core A in the present machine acted as the crossbar for B, and B as the crossbar for A, or the one completed the magnetic circuit for the other. The deflection caused by the current [E.M.F.] produced in this device, everything else remaining the same, exciting currents, speed, &c., was 43deg. Or if we compare the tangents of the angles of deflection, the strengths of the currents [E.M.F's.] were in proportion as ·57 to ·93. The machine had evidently been improved by this alteration. Each conductor cut the magnetic current at the two cheek pieces F and H and also at the cheek pieces E and G, and the currents produced were added in the conductor. The machine had really two armatures A and B, each rotating in a field of force of its own. Both fields of force were, however, in the same magnetic circuit, and the conductor cut the same lines of force four times during each revolution. Once between F and A, again between A and E, again between H and B, and also between B and G, substantially as in the arrangement shown in the unipolar machine (Fig. 7). But while in the unipolar machine the four armatures were operated independently of each other, the two armatures in the present machine were mounted on one shaft and rotated together. Now the conductor being in one piece and the cheek pieces one each side of like denomination, the armatures were in series and the currents produced were therefore added. Taken in connection with the experiments with the unipolar machines this seemed to prove that a magnetic circuit could be cut any number of times and fields of force for the generation of currents produced, provided the resistance in the field of force is no greater than in other parts of the circuit.

The question now presented itself in this way:—Was the improvement due to the fact that each conductor passed through the same magnetic circuit twice in each revolution? Or, was it due to the fact that two electro-magnets, each of the same cross-section as the first, were used? To determine this question, a new electro-magnet was made and applied to the cheeks, and the experiments repeated.

The electro-magnet is shown in front view in Fig. 13, and in vertical cross-section in Fig. 14. It consists of a bar of wrought-iron, wide enough to reach over two cheek pieces, and bent in horseshoe shape, as shown in Fig. 14. This bar was again wound with the same quantity and size of wire as the two horseshoe magnets, and the bar magnet used in the previous experiments. Under the same conditions as were the preceding experiments, the machine furnished a current [E.M.F.] which deflected the tangent galvanometer to 45 deg., or 2 deg. more than the one with two magnets. Many other alterations were made. The same quantity and length of wire was wound upon four curved bars, and these connected to the cheek pieces. And, finally, two broad magnets, like the one shown in Figs. 13 and 14, each wound with one half the quantity and length of wire, and placed on both sides of the machine were tried. All the experiments had been made under precisely similar conditions, viz., the same quantity and length of wire in the electro-magnets, the same exciting currents in the

FIG. 13.

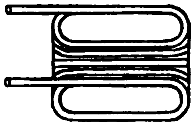


FIG. 14.

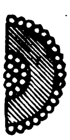


FIG. 15.

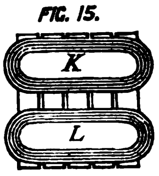
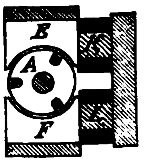


FIG. 16.



electro-magnets and the armature revolving at the same speed. The current [E.M.F.] produced deflected the galvanometer as follows:—

One magnet (Fig. 11), 30 deg., tangent .... = 0·5774
Two magnets (Fig. 12), 43 deg., tangent........................ = 0·9325
One broad magnet (Figs. 13 and 14), 45 deg., tangent...... = 1·00
Two broad magnets (Figs. 13 and 14), 62 deg., = tangent.. 1·8807

Step by step, as the cross section of the electro-magnets had been increased and the resistance in the magnetic circuit reduced, the machine had been improved. The electro-magnet has been shortened in each instance, and its cross section increased. It seemed as if this process could be carried on indefinitely, and it was therefore decided to experiment in another direction. Two cross bars, K and L, of wrought iron were secured upon two cheek pieces, as shown in side view (Fig. 15), and in vertical cross section (Fig. 16). Each bar was surrounded by a helix, as at K' and L'. The same quantity of wire as in all previous experiments was used in the coils, and the cross section of the bars K and L was equal to the cross section of the broad magnet, shown in Figs. 13 and 14. Suitable bars of iron, M, were provided to connect K and L, and thus completed the magnetic circuit. When the magnets were excited as before, and the pieces of iron M M had the same or a greater cross section than K and L, the current [E.M.F.] produced by the armature deflected the galvanometer to the same extent that it was deflected when the broad magnet (Figs. 13 and 14) was used. By the removal of some of the bars the magnetic circuit could be gradually reduced, and the resulting change in the current (E.M.F.) was about as follows:—If the whole cross-section of the electro-magnet be 100, and the current [E.M.F.] value, when the full cross-section of the magnet is used, be also called 100, then the the cross-section bore about the following proportions to the current:—

Cross-section.	*Current [E.M.F.]*
100	100
70	80
33	52
22	37
15	25
$7\frac{1}{2}$	11

These figures seem to indicate that the current [E.M.F.] does not bear the exact proportions of the cross-section of the magnetic circuit. As the cross-section of the iron was reduced, its relative value as a conductor of the magnetic current seemed to increase—an increase probably due to the fact that a greater part of the magnet current completed its circuit through space than when the whole current was carried by the metal. It seemed evident that the value of the magnetic circuit is equal to that portion which offers the greatest resistance to the magnetic current, and that the magnetisation of the point of highest resistance is the true measure of the efficiency of the machine. In all dynamo machines that point is where the magnetic current passes through space from the cheek pieces to the armature core; or when an armature without magnetic metal is used, where the magnetic current passes from one cheek piece to the other.

(To be continued.)

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SWITCHES AND AMMETERS.

It is generally thought that the Electrical Power Storage Company restrict their operations to the manufacture of secondary batteries, but this is not so. They are manufacfacturers of various descriptions of electrical apparatus. Amongst others, they make a series of switches, which have been found to work very well in their installations. Those shown in Figs. 1 and 2 consist of a lever which

Fig. 1.

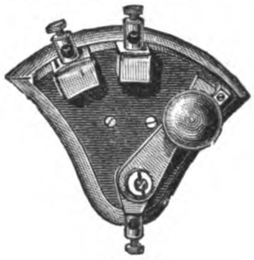


Fig. 2.

completes the circuit by passing between the overlapping hard sheet brass lipand the solid terminal pieces, making a reliable and clean connection, while a sharp break is obtained, sparking thereby being reduced to a minimum. This type of switch is employed for currents of from 20 to 60 amperes, and is now invariably used in preference to the older type switch, Fig. 3, which, although reliable at first, is likely to get out of order, owing to its dependence upon a spiral spring for perfect metallic connection.

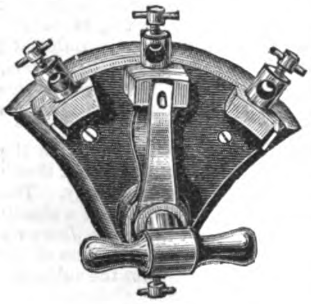


Fig. 3.

The switch, Fig. 4, is an arrangement for automatically making and breaking the charging circuit of a secondary

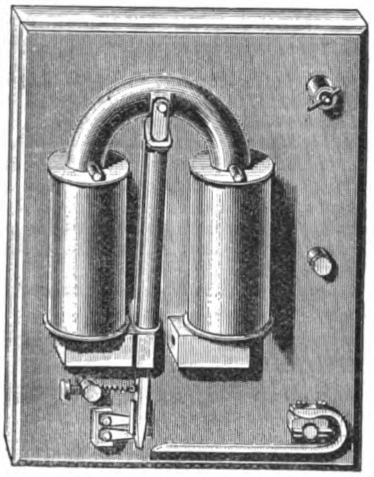


Fig. 4.

battery at the correct moment, the circuit being closed soon after the E.M.F. of the dynamo exceeds the counter E.M.F. of the battery terminals by a predetermined amount, and broken as soon as the current falls to zero, the rupture of the current being accomplished without the slightest sparking. The centre tongue pole of the magnet is wound with fine wire in parallel with the fine wire coils on the outer legs of the magnet. When the E.M.F. of the dynamo reaches the desired amount, the centre tongue pole is attracted against the pressure of a spiral spring to an opposite magnetic pole of the electro-magnet, and as the "tongue pole" moves forward, it closes the main circuit at the contact spring, simultaneously breaking the

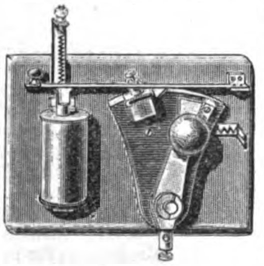


Fig. 5.

THE E.P.S. SWITCHES AND AMMETERS.

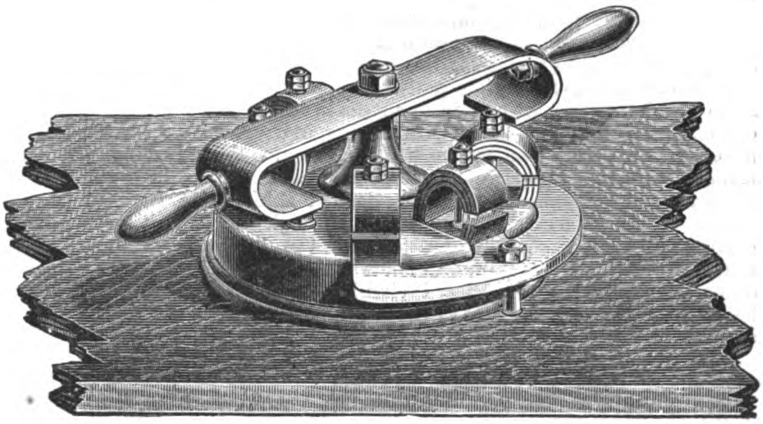
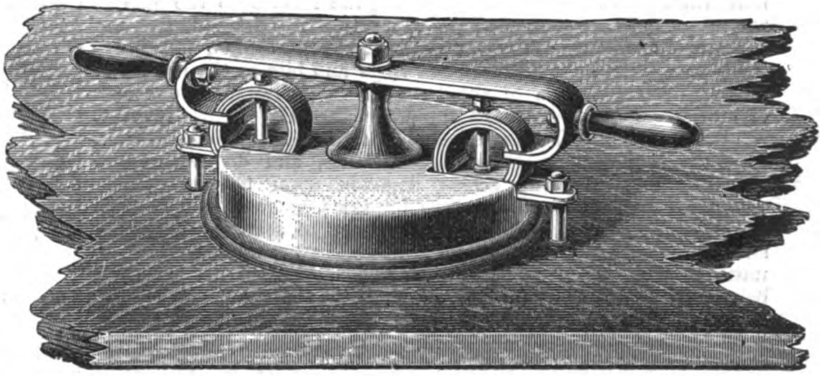
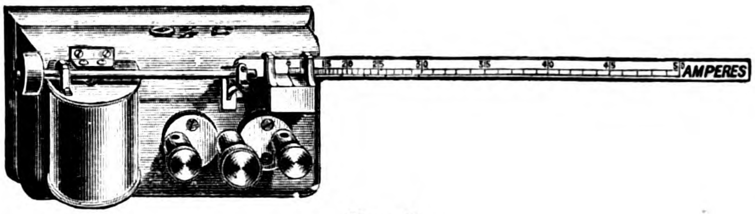


Fig. 6.



Figs. 7.



Figs. 8.

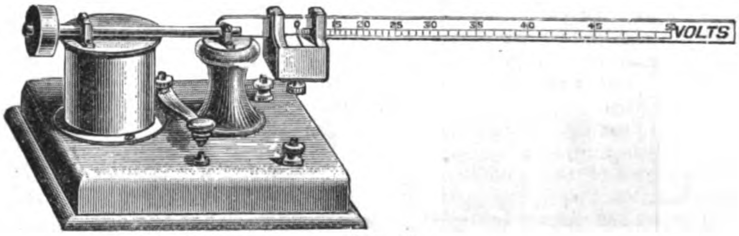


Fig. 9.

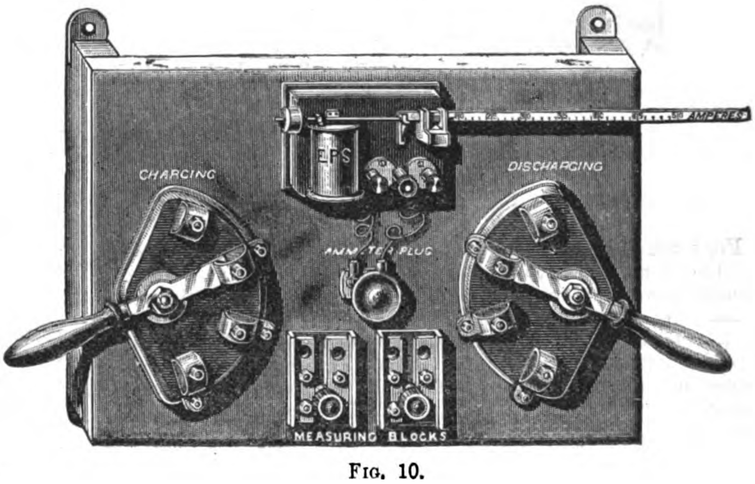


Fig. 10.

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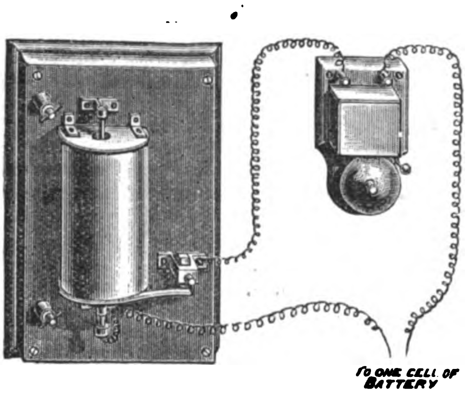
shunt-circuit round the outer legs of the electro-magnet. This position is retained while current is passing in the main circuit, because the whole current is conveyed around the outer legs of the electro-magnet. It will be clearly seen that a failure of the main current will allow the spiral spring to draw back the contact tongue and break the main circuit, at the same time putting the shunt coils of the outer legs of the electro-magnet again in circuit in readiness for a renewal of sufficient E.M.F. for the purpose of charging. A cheaper switch to effect somewhat similar work is shown in Fig. 5. This is termed a "Mousetrap Switch." It is placed "on" by hand as soon as the dynamo renders the desired E.M.F. indicated by voltmeter or otherwise, and the coil through which the main current passes immediately draws down the lever, to which is attached a piece of soft iron, and holds the switch lever on, or, in other words, maintains a closed circuit; when the current falls below a certain limit the core of the solenoid is weakened to such an extent as to allow the lever spring to draw away the detent and release the switch lever, which is drawn out of contact by its controlling spiral spring.

For heavy currents the "ring contact" switches have been designed, shown in Figs. 6 and 7. The connecting terminal clips in this instance consist of one or more split rings placed inside one another, and diagonally in opposite positions on the switch base, the contact being made by forcing the lever into the gap in the rings. The safest possible connection is obtained, and the surfaces through which the contact is made and broken are always self-cleaning. The tension on the rings and bite on the lever can be adjusted by means of the bolt running through the centre of the rings. The steelyard ammeters and voltmeters, designed, we believe, by Mr. Drake, shown in Figs. 8 and 9 on previous page, are found to be thoroughly reliable, and do not require re-calibration, as their action depends upon the magnetism developed in a charcoal iron core by the passage of a current on the surrounding coil. The readings, as will be seen, are taken by sliding the weight along the rod on the ordinary steelyard principle, until the attraction of the electro-magnet or its armature is exactly balanced by the weight.

The switch-board (Fig. 10) consists of two "single ring contact" lever handled switches for regulating the number of cells in the charge and discharge circuits, also two sets of measuring blocks for the purpose of inserting the ammeter at will into either charging or discharging circuits. Seven standard switch-boards, designed on the same principle for use in the accumulator installations, are made, the largest being fitted throughout with switches capable of carrying 1,000 amperes. Neatness is a special feature in these boards. They are of polished teak, and no cables whatever appear on the front, provision being made at the back for all the main connections; this is effected by means of bolts running from the contact blocks through the board, and fitted at back with tinned cups, into which the cables are soldered. All the necessary connections from switch to switch are made before the boards are issued.



AUTOMATIC ALARM FOR DISCHARGING CIRCUIT

FIG. 11.

For some time past it has been evident that apparatus which would call attention to the excessive discharge rate of the cells would be invaluable in installations, and reduce to a minimum the liability of spoiling cells by this means. The automatic alarm (Fig. 11) was designed to meet these requirements. The main discharging current passes through the coil in which a soft iron core is freely suspended. As soon as the safe discharge rate is reached, the core is drawn into the coil to its full distance, thus completing the local bell circuit, and giving warning that the number of lamps must be reduced, or that the generating machinery must be started.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

A meeting of the Society of Telegraph-Engineers and Electricians was held on Thursday, the 24th March, at the Institute of Civil Engineers, Westminster, the President, Sir Charles Bright, in the chair, when the following paper was read:—

THE RESISTANCE OF FAULTS IN SUBMARINE CABLES.

BY A. E. KENNELLY, M.S.T.E.

Foremost among the problems which occupy the attention and tax the ingenuity of telegraph-engineers and electricians is that which relates to the measurement of the resistance in, and up to, such faults as may develop in the circuits conveying their currents; and the accuracy with which this measurement can be conducted is a subject of great technical, and frequently of considerable economic, interest. New facts, therefore, which tend to elucidate the phenomena that faults present, or new methods that lend aid to the measurement of their quantities, need no apology for their presentation to those practically interested in telegraph work. It is with the view and in the hope of aiding in both those directions that the present paper is submitted to this Society.

Although there can be little doubt that the laws which are about to be stated control all faults in sea water, yet their practical application will be found to be limited to large, open exposures, such as occur in the majority of cases where cables are totally broken. On this account we shall confine our attention to "total breaks."

Although there are many different methods in use for the measurement and elimination of the resistances of faults, or partial earths, in cables, there has been up to the present time apparently only one published method for measuring the resistance which the broken end of a cable offers, and that—due, we think, to Mr. H. R. Kempe—is based upon the measurement of the amount of discharge from the cable immediately after a balance has been obtained by Wheatstone's bridge.

The difficulty which is so frequently met in executing this test is the elimination of the rapidly falling polarisation current from the first throw of the galvanometer needle, which should register discharge only. The formulæ for separating the effects upon a galvanometer needle, of a steady current from a discharge current combined, are published in the *Journals* of the Society; but when the polarisation current is a large fraction of the discharge, its rapid fall in intensity still further complicates the subject.

The course, therefore, almost invariably adopted for localising a break by the tests from one end of the cable only is, as we all know, to reduce the break's resistance by suitable methods, such as Lumsden's, to an apparent practicable minimum, and then to estimate the value of this minimum from the general "behaviour" of the break, *i.e.*, its variability under varying testing currents.

In practice, the most common minimum resistance of a break arrived at in this way may be placed between 10 ohms and 40 ohms; less frequently between 5 ohms and 75 ohms; while in rare cases the limits zero and infinity are approached. In the former case the conductor is in firm metallic communication with the sheathing of the cable, and in the latter the end of the conductor is so nearly enveloped by its gutta-percha covering that the hydrogen evolved in testing completes the seal.

Although an experienced judgment very frequently enables an observer to estimate accurately the resistance of a break, still not only is this a very unscientific means of arriving at the result in the present condition of electrical knowledge, but occasionally accidental circumstances may interfere with the accuracy of these estimates, and it would be a great advantage gained for an observer if he were enabled to bring actual measurement as a check upon his judgment.

Besides the above-mentioned method by discharge measurement, various expedients appear to have been brought forward at different times with the object of comparing the relative variations in resistance that different breaks exhibit with different battery powers, and so arriving at comparative results for any given break. Mr. Latimer Clark in the first instance, in 1862, and Sir Henry Mance so lately as May, 1884, have published tables of the relative resistances of different exposures, under certain conditions of electromotive force, resistance, and time. In fact, formulæ have been prepared based upon such experiments—notably, we believe, by Mr. R. K. Winter and Mr. B. Smith. It is probable that the necessarily empiric character of such formulæ, not claiming to be based on any generally recognised law of electricity, has stood in the way of their wider acceptation.

Underlying all these facts there seems to have been the consciousness of an unexpressed law. It has long been known that the resistance of a fault diminishes when the current-strength passing through it increases, so long as the exposed surface is maintained constant; but the rate of the diminution for a given current increase seems to have hitherto evaded inquiry. Still it is only consistent with all the accepted doctrines of energy that the rate of diminution must be in obedience to some particular mathematical laws. In fact, Mr. Latimer Clark's words may be quoted from his remarks on Sir Henry Mance's paper of May, 1884, already referred to: "There evidently is a law, or set of laws, running through the figures, which could be put into the shape of formulæ, and made of use to the practical electrician."

The results of a series of experiments extending over several months, made with a view to studying the rate of diminution in resistance for increasing current strengths, seem to show that all faults obey two simple, mutually supporting, conjugate laws, whose effects, however, in practice appear to be greatly masked and encroached upon by disturbing influences of a physical nature. It is therefore desirable to examine the subject from its theoretical aspect at first; and when the truth of these laws is represented we can proceed in confidence to seek how far their operation can be practically depended upon.

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The two laws may be stated thus (they refer to one direction of current at a time only):—

I. When the exposed area is constant, the current strengths passing through the exposure are inversely proportional to the squares of the resistances which the exposure respectively offers.

II. When the current strength passing through the exposure is constant, the areas of exposure are inversely proportional to the squares of the resistances which the exposure respectively offers.

These are laws of inverse squares. For practical purposes the following enunciation in terms of inverse square roots is preferable:—

I. The resistances of a constant area vary inversely as the square roots of the current strengths.

II. The resistances to a constant current vary inversely as the square roots of the exposed areas.

So that, if these laws are true, we halve the resistance of an exposure either by quadrupling the strength of the traversing current, or, if the current remains unaltered, by quadrupling the exposed area.

It is easily seen that the demonstration of one of these laws causes the truth of the other to follow as a corollary. For assuming, say, the first law, and that a certain exposed surface (s) offers a resistance, r, to a particular current-strength (c), then when another current, $\frac{c}{n}$ (where n is not necessarily an integer), passes through the exposure, its resistance becomes by hypothesis,

$$r\sqrt{n}.$$

Now suppose that the original current c is maintained unaltered, but that the surface of exposure s is altered to $n\,s$ (where the value of n is independent of that assigned in the previous expression), then the strength of current passing through the exposure per area s has changed from c to $\frac{c}{n}$, and we have seen that the resistance of each area s must have become $r\sqrt{n}$ in consequence. But there are n of these areas, connected together in multiple arc, and their combined resistance—that is, the resistance of the whole surface

$$n\,s = \frac{r\sqrt{n}}{n}$$
$$= \frac{r}{\sqrt{n}}.$$

The form of this equation proves that the resistance varies inversely as the square root of the exposed area—the second law.

It is interesting to observe that among all the functions of n by which we could conceive a law to take effect, the square root of n is the only one that makes the two laws conjugate as above. For suppose it were found to be true by experiment that the resistance of an exposed surface did not vary as the inverse square roots, but as the inverse cube roots, of the current strengths traversing it, then it would follow that with a constant current the resistance of an exposure would vary inversely, not as the square root or cube root, but as the cube root squared, of the exposed area.

For, by the above reasoning, if when s is constant, the resistance with $n\,c = \frac{r}{n^{\frac{1}{3}}}$, then when c is constant the resistance of $n\,s = \frac{r\,n^{\frac{1}{3}}}{n} = \frac{r}{n^{\frac{2}{3}}}$; and so on.

It becomes, therefore, only necessary to confine our experiments to the measurement of the resistances offered by varying exposures to the same current in order to arrive at the law of the resistances offered by a constant exposure to varying currents, and perhaps the former is the simpler experimental problem. But, whichever plan is followed, the great source of error and difficulty in making these experiments is found, as might be expected, in polarisation.

It interferes, as we all know, in three ways—1st, mechanically, because when either gas or a metallic salt accumulates on the exposure, the area exposed to free liquid contact is reduced to an extent that it is impossible or very difficult to ascertain; 2nd, electrically, because the gas generated opposes a varying electromotive force to the testing current, which is thus altered from the strength calculated for, and the exact correction is difficult to arrive at; 3rd, electrically, because this electromotive force of polarisation existing in the circuit whose resistance is to be measured causes a large error to be made in the measurement, and owing to the great rapidity with which it falls, the moment the testing current ceases, the exact correction to apply is difficult to obtain.

Of these three errors the last is generally by far the greatest, and has probably been chiefly instrumental in enabling the laws of fault resistance to evade exact inquiry.

If the polarisation electromotive force were constant, or if it varied at any known rate, it would of course be readily possible to find the extent of the third error in any given balance or measurement. But the rate at which it falls after the cessation of the testing current is apparently not clearly known, and would seem to be dependent on chemical conditions, the elements of the charging and discharging circuits, and time. Profs. Ayrton and Perry, in a very interesting communication to this Society's *Journal* (Volume V.), have recorded observations on the subject, but they mention that during the first few seconds after the removal of the testing current, in their experiments, the fall of polarisation electromotive force was exceedingly great, and beyond the registering capabilities of the apparatus they employed. In fact, apart from all electrical fall of potential by discharge, if this polarisation electromotive force has its chief seat in the contact of the developing gas with the metallic surface of exposure, which gas is continually being given off either in bubbles or in solution, then on the cessation of the testing current, as soon as the gas last developed has had time to quit the surface of the exposure—no doubt for a large quantity of it only a very brief interval—the electromotive force due to the presence of that gas has disappeared from the circuit.

The following experiment will show how greatly the interval of time between the cessation of the testing current and the observation of the polarisation electromotive force for correction affects the results obtained.

It may be premised that all the measurements in this paper have been taken with the Wheatstone bridge, and the corrections for the third polarisation error mentioned above have been all effected by reading to the polarisation current as zero, or by what is commonly called "false-zero" reading.

Experiment.

From a sheet of tinned iron 0·5 mm. thick, eight plates were cut, each approximately 15 cms. by 2 cms., with a copper wire soldered to one end. They were then immersed in salt water, by means of a suitable frame, to about 7 cms. in depth, each plate thus exposing about 28 sq. cms. of surface to the water.

The resistances of various combinations of these exposures were then measured directly by Wheatstone's bridge, with a current maintained at 10 milliamperes in the exposure arm. By means of a metronone striking a bell at one, two, or more seconds, the time intervals were appreciated between the cessation of the testing current and the observation of the polarisation "false zero."

The table shows the comparative resistances measured in this way, the zinc pole of the battery being to bridge.

TABLE I.

No. of Series.	Strength of Current through Total Exposure.	Interval of Time between Cessation of Testing Current and the Observation of the False Zero of Polarisation.	Number of Plates connected in Parallel Circuit, and the corresponding Resistance observed.								Mean Coefficient of Resistance in each Series for a Doubled Area of Exposure.
			1	2	3	4	5	6	7	8	
	Milli-amperes	Seconds.	ω	ω	ω	ω	ω	ω	ω	ω	
1	10	...	12·5	9·1	7·5	6·3	5·8	5·3	4·9	4·6	0·714
2	,,	1	48	43	39·5	36	33	29	26	22	0·770
3	,,	2	55	52	48	44·5	39	34·5	31·5	28	0·789
4	,,	3	62	57·2	52·5	45·5	43	41	39	36·5	0·826
5	,,	4	64·5	59·5	53	49	46·5	44·5	42	39	0·845
6	,,	5	66	61·5	56	52	48	45·5	43	40·5	0·842

Here the apparent resistance of exposures with 1, 2, 3, . . . to 8 plates —corresponding to about 28, 56, 84, . . . to 224 square centimetres—is shown in respect to time. Series No. 1 is supposed to have been observed at an exceedingly small interval after the cessation of the battery current, in a manner to be presently described. It may be called the series at 0 seconds, or the series taken to "immediate false zero." The false zero so observed would therefore be the correct measure of the polarisation electromotive force during the last flow of the testing current, and consequently the observed resistances in this series No. 1 should be the actual resistances which that current encountered. It will be seen that the results obtained in this series follow the law of inverse square roots closely; that is to say, the resistance is approximately reduced one half by quadrupling the exposed surface. The coefficient of resistance reduction for a doubled surface by inverse square roots is of course $\frac{1}{\sqrt{2}} = 0{\cdot}707$, and the mean coefficient in this observed series is

$$\frac{\frac{9{\cdot}1}{12{\cdot}5} + \frac{6{\cdot}3}{9{\cdot}1} + \frac{5{\cdot}3}{7{\cdot}5} + \frac{4{\cdot}6}{6{\cdot}3}}{4} = 0{\cdot}714.$$

The difference between the observed and calculated coefficients is 0·007, or about 1 per cent. This discrepancy may be accounted for either by error of observation, by the interval of time between the cessation of the testing current and the false-zero observation not approaching zero closely enough, or by any extraneous resistance in the exposure circuit between the face of the liquid envelope and earth. The last two sources of error would inevitably increase the observed coefficient.

Series No. 2 was taken with a false zero, observed at one second's interval after the testing current ceased. The table shows that the balanced resistances have, by this means of observing, risen 300 or 400 per cent. The mean coefficient of resistance reduction for a doubled surface is now 0·770, or about 10 per cent. more than the law of inverse square roots would warrant.

Series No. 3 was observed to a false zero, two seconds after the cessation of the battery current. The observed resistances are now 400 or 500 per cent. above the corresponding resistances in series No. 1, and the mean coefficient for doubled surfaces is now apparently 0·789, which is nearly what would be expected if the resistance varied, not as inverse square roots, but as the inverse cube roots of the exposed surface, namely, $\frac{1}{\sqrt[3]{2}}$, or 0·794.

In series No. 4, taken to a false zero at three seconds, the apparent resistances are 400 to 700 per cent above the corresponding resistances in series No. 1, and the mean coefficient for doubled surfaces appears to be 0·826.

In series No. 5, taken to false zero at four seconds, the difference in the readings from the corresponding observations in the preceding series is

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less than has previously been the case ; that is to say, the fall of polarisation electromotive force rapidly slackens after three seconds have elapsed from the cessation of the testing current. The mean coefficient for doubled surfaces now appears to be 0·845, or about what would be expected from a law of inverse fourth roots, namely, $\frac{1}{\sqrt[4]{2}}$, or 0·841.

The same remarks apply to series No. 6.

In the tables appended to Sir Henry Mance's paper above mentioned, appearing in No. 53 of the Society's *Journal*, the observed coefficient for doubled surfaces of exposure is seen to vary between 0·80 and 0·95. The current strengths, however, do not appear to have been constant during the different series, so that it is difficult to establish any exact line of comparison between those and the results of Table I.

In observing such a series as No. 2, when for a particular exposure a balance has been obtained, we notice, on releasing the key that applies the testing current, that the galvanometer spot takes a rapid swing in the direction denoting less balancing resistance required, but that it very soon stops and returns along the scale with great but diminishing velocity.

The above table shows the effect on the quantity of balancing resistance brought about by the selection as zero of any particular distance in time along the spot's path. Now, if, as was in this experiment observed, there is no appreciable electrostatic or electro-magnetic capacity in any of the arms of the bridge to disturb the galvanometer on opening or closing the battery circuit, the rush of the spot in the first direction must be due to the polarisation electromotive force existing in the exposure circuit during the last moments of testing current flow, and consequently the correct position of the spot to select as zero is that position which in its first throw it endeavours to reach. Accordingly, in observing series No. 1, the balancing resistance was reduced step by step until this first throw was so far diminished as to be no longer appreciable. So rapid is this first throw that perhaps the vanishing limit was not actually attained, and the resistances may therefore be slightly in excess of their true values. This may account for the slight discrepancy between the observed and calculated coefficients already mentioned.

(To be continued.)

COMPANIES' MEETINGS.

Direct Spanish Telegraph Company (Limited).

The twenty-seventh ordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, on Monday last, under the presidency of Sir James Anderson.

The MANAGER (Mr. Charles Gerhardi) read the notice convening the meeting, and the minutes of the last meeting, which were signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN : I have very little to remark upon the report, which is plain enough. The expenditure is £22 more for the past half-year than for the previous six months, although it is £200 less than for the corresponding period of 1885. The increase in the past half-year is entirely owing to the increase of traffic, which necessitates, of course, the use of more stationery, and also a little more for salaries. Since our last meeting, as you are doubtless aware, we have been in the law courts, and we have reduced our capital by half. As the report tells you, the capital, as reduced, has now got a quotation on the Stock Exchange. I believe, gentlemen, that this position of affairs has given very general satisfaction to our shareholders, because, with the exception of two or three, all have signified their assent. Two gentlemen, I think, were rather hard upon us. They scarcely objected in what I would call a friendly spirit ; but I have sympathy with them, because I myself entertained for a long time—as long as I could—the feeling that it was a very hard thing to do to reduce the preference shares in the way we have done. However, after every kind of thought and consideration had been given to the subject, we found that we could not help ourselves. The law stood in the way, and said we should only do what we wanted to do in a given fashion. We had to go to the Court to see how they took it and how they would put it. One judge, as you know, did not agree with us, and did not sanction our plan for reducing the capital, but he did not say what other plan we should adopt, and did not say anything that appeared to us to establish law on the subject. We were advised by our counsel and solicitor that we were as much in the dark as ever, and that we had to appeal. As you know, we appealed, and the judges in the Court of Appeal fully confirmed and affirmed all that we had proposed, and considered that there was no other right way of going on. Assuming that the Court of Appeal had taken the same view as the first judge took, we should not have been any better off. We should have been obliged to go into court again to see what we should do, for we could not, as the law stood then and stands now, have paid any dividend at all until we had recouped our lost capital, because our assets were positively lost to the extent we named in our resolution. Therefore, we must have gone into court again. Some one must have put us there before we could have paid anything, or else we should have gone on for a number of years with our revenue locked up, and, as I said before, at a former meeting, we should have been whipping a dead horse. We have now, however, got the Company into this position—we have reduced the capital by one half, the preference shareholders have had £5 a share taken off their fully paid £10 shares, and the ordinary shareholders have had £5 taken off their shares, which had £9 paid up, and they still have a liability of £1 a share. That is about £13,000 in hand to support the property in the hands of the debenture holders and the preference shareholders. This was remarked upon by the judge who granted the petition for reduction of capital as withal a little hard upon the ordinary shareholders ; so while we were sympathising—I and many others, at least—with the hardship which the preference shareholders had to encounter, the judge, who knows these things better, I suppose, than we lay people do, was sympathising with the ordinary shareholders. Taking it altogether, I think we have got into a very fair position, and there is this satisfaction, that we are now a going concern, a marketable security, earning a dividend, and likely to continue to do so. You will remember that at the last Berlin Telegraph Conference our tariff was reduced to a very low figure. There was a reduction of 20 per cent. in our tariff, and still, notwithstanding that, thanks to the commercial treaty, no doubt, thanks to some revival of trade, and thanks to the reduced capital, we are earning a dividend, and have increased the number of our messages by 26 per cent., while we are earning 6 per cent. more money. I therefore look forward to the next time we meet, six months hence, to be in a position not only to lay by the reserve, which we consider adequate, and pay the accumulated interest on the preference shares, but to pay a dividend of not less, I hope, looking at the traffic we are now having, of 4 per cent. on the ordinary shares. I cannot, of course, say it will be 4 per cent. ; it may be even 5 per cent., but that depends on the traffic keeping up. Just now we are fairly satisfied, having earned £300 more in the first three months of this year than we did in the same period of 1886. That on a small capital is a good deal. I do not think I have much more to say. I congratulate you, as I congratulate myself, on being in a small company now earning a dividend, and I begin now, as a telegraph man, to envy those companies which, with a low tariff—a tariff reduced to a point below which they are not likely to be driven in a hurry—are still able to earn dividends. The tendency in these days seems to be to force companies down to the smallest revenue and the smallest tariff the public can get them to, and I believe in our own case that we are at that point. That we can continue to earn dividends with this low tariff is to me very satisfactory, and I believe you will have now a good security in the shares of this Company. I now move : "That the report and accounts now presented be and they are hereby received and adopted."

Mr. EDMUND ETLINGER seconded the motion, which was carried unanimously.

Mr. DYETT urged the Directors to exercise every economy, and said he thought the expense of hiring a room for the meetings might be saved by holding them at the offices. He also made a few remarks on the item of stationery.

The CHAIRMAN said that their plan in regard to stationery was to get tenders. As to the expenses in connection with holding the meetings, he did not think that £4. 4s. a year was much to pay for the hire of rooms.

Mr. HUGHES-HUGHES asked whether the Directors intended to form a reserve fund. The Chairman had spoken about paying a dividend on the ordinary shares, but it was to be remembered that the Company lost so much capital through not having a reserve fund.

The CHAIRMAN said that a reference to the report would show that the Directors had carried to the credit of the reserve fund the sum of £3,577, and the resolutions sanctioned at the two previous meetings provided for £5,000 a year being added to the reserve fund. Continuing, he moved the re-election of Mr. Etlinger.

Mr. J. DENISON PENDER seconded the resolution, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. ETLINGER, Mr. J. Denison Pender was also unanimously re-elected to his seat at the Board.

Mr. DYETT said that he supposed that the item of legal expenses represented only the ordinary legal expenses, and that the special expenses connected with the reduction of capital had yet to be charged against the Company.

The CHAIRMAN replied that all the expenses had been charged, and that the next balance-sheet would be found to be on the ordinary lines of a commercial balance-sheet.

The SOLICITOR (Mr. Blunt) said he might point out that two-thirds of the law charges were really for expenses out of pocket and for counsel.

Mr. LOWE : Due to our friend, Mr. Bannatyne.

The CHAIRMAN : He had to pay some.

On the motion of Mr. LOWE, seconded by Mr. DYETT, the auditor, Mr. Herbert R. Duke, was re-elected.

Mr. HUGHES-HUGHES then proposed a vote of thanks to the Chairman and Directors. They had had some hot water to go through, but he believed the dissentient shareholders were absent from that day's meeting. He might say that he had been one of them on behalf of a widow for whom he was trustee, but the Court had said that what the Directors proposed was the right thing.

Mr. LOWE seconded the motion, which was unanimously agreed to.

The CHAIRMAN, in replying, said he was very glad that they had arrived at the present position of matters, for he believed that they now possessed a good security, one he would not be afraid of putting money into himself, or advising his friends to invest in.

The meeting then separated.

Electrical Power Storage Company (Limited).

The sixth ordinary general meeting of the Electrical Power Storage Company was held at the City Terminus Hotel, Cannon-street, yesterday, under the presidency of Sir Daniel Cooper, Bart., K.C.M.G.

The SECRETARY (Mr. Holland Dell) read the notice convening the meeting. The report and accounts were taken as read.

The CHAIRMAN then said : I feel more pleasure in addressing you to-day than on any previous occasion, and my task is an easy one. We have a profit of £35,937. 11s. 3d., which enables us to write off the amount

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standing to the debit of profit and loss, viz., £222,412. 6s. 9d., and to carry forward a balance of £13,525. 4s. 6d., and I am not aware that any company engaged in similar business has done so well. The largeness of this profit may have caused some surprise, and I would mention that a considerable portion of it is of an exceptional character, and occurs through some interests becoming marketable since the date of the last balance-sheet, the value of which we felt bound to include; but, on the other hand, a substantial amount of it is trading profit. We have got rid of the evil legacies of past years—that is, the debit balance in the profit and loss account—and are going forward with a clear sheet, when whatever we make can be divided among the shareholders. It is natural for some of you to wish to know why, with this large profit, the Directors do not propose to recommend a dividend. The reason is, that with the increasing business of the company, and the amount of capital required for carrying it on successfully, we must not diminish our cash working capital. I will now comment briefly upon some of the subjects dealt with in the Directors' report. I am glad to say we have had no litigation in England during the past year, there has been no necessity for any; but we have carefully watched, and shall continue, to watch all those who seem inclined to interfere with your property. You are aware that this Company owns a numerous group of patents, among which are the first patents granted for secondary batteries; and I only call attention to what is a matter of public observation in saying that the obvious tendency of recent patent decisions has been to increase the value of our patent rights. In addition to the license granted last year to the Elwell-Parker Company, we have granted a license to the Edison and Swan United Electric Light Company to manufacture certain types of secondary battery plates; and we have taken similar steps in other directions with the object of urging forward the application of accumulators to the propulsion of tramcars, which branch of business is beginning to attract the attention it deserves. The successful adaptation of this Company's batteries in the electrical launch attached to the steam yacht, "Northumbria"—where some of the cells placed in the launch itself supply motive power for the launch, and are also capable of furnishing light when desired—should induce the extensive use of batteries for this purpose. The train lighting by electricity I take much interest in, and I expect to see this year a considerable development of this branch of electrical work. I feel sure that the public will appreciate the efforts of those railway companies who are desirous of adding to the comfort of passengers by materially improving the lighting of their trains. The lawsuit in France has not yet come on for hearing—it will, probably, during the summer. Negotiations have been begun and will be continued on the Continent for the purpose of getting local people to interest themselves in the accumulator business. The value of secondary batteries is gradually becoming recognised throughout Europe. In Germany the claim made against the Faure patent is still before the Courts. Our attention has been called to several secondary batteries on the Continent, and we have examined into them; they have no special merits, and the principal ones are obvious infringements of some one or other of our patents. The installations at the various banks and offices mentioned in the report were successfully carried out since our last meeting, while the older ones, such as the Bank of England, the Peninsular and Oriental Steamship Company, the Bank of New South Wales, Lloyd's, and many others continue to give satisfaction. We are supplying accumulators to the Admiralty and War Office, and we number among our customers several foreign and colonial Governments. We are determined to keep well ahead in our work, and our technical staff, under the direction of Mr. Frank King, our superintending-engineer, have for several months past given the closest attention to certain details of manufacture, with a view of securing the highest excellence, and such improvements in the batteries as may be possible. You will have read, doubtless, with pleasure the description, from the (New York) *Electrical Review*, of the position and progress of the Electrical Accumulator Company in New York. It is just what I should expect from a sound enterprise, when handled by such a man as Mr. Vail. They have the advantage in the States of not being unduly fettered, as we are in this country; but the Bill of Lord Thurlow has been so well received by the public, that, backed by the powerful support of the Prime Minister (Lord Salisbury), I think the electrical industry will be granted a considerable measure of relief during the present session. In conclusion, I have to say that any more information that may be desired will be given if compatible with the interests of the shareholders. I beg to move the adoption of the report and accounts.

The VICE-CHAIRMAN (Mr. John Scudamore Sellon): Gentlemen—In seconding the resolution, I can scarcely do more than congratulate you on the success attained by the Company during the past year. There is, however one matter to which I may call your attention, as it bears upon the value of your property, namely, the position of the patents owned by the Company on which the Chairman has slightly touched. What makes the subject, perhaps, of special interest to you just now is that in a prospectus which was recently before the public some extraordinary pretensions were put forth, and of such a nature that many of my friends who are large shareholders in this Company were quite staggered by them, until I was able to assure them that the statements in question must be accepted with a great many grains of salt, that the *modus operandi* proposed, namely, the distribution or supply of batteries from house to house, was impracticable, and that holding, as we do, a complete group of patents, which together cover the essential principles of every known practical and successful form of secondary battery, our position is fully protected. Even supposing that the company in question could succeed in establishing the business of supplying electrical accumulators, they must eventually come to us for a license, and this is a point upon which your Directors hold business-like and liberal views, knowing that the ground to be covered with such work is rapidly extending, and that there will be room for many in it. You hold what might be made a practical monopoly—a gigantic monopoly; but it is not perhaps good policy to throw impediments in the way of the development of such a business as this may become, so long as your rights are recognised and protected. It has been suggested that the present form of secondary battery may be superseded, but all that is at present known tends to prove that that is not likely to be the case. The subject is one of such great importance that it has exercised the minds of the most talented electricians of the world. Yet, as we all know, no material departure—no new departure—has been as yet made from the principles which were laid down in the year 1881 by Faure, Swan, and myself. You may therefore feel assured that the essential principles, at any rate, of secondary batteries are covered by these patents; and although it may be possible that minor improvements of detail may be gradually arrived at, yet if such improvements are made by outsiders, naturally they can be brought within our control. I have had some satisfaction in feeling that every statement of mine made years ago as to the development and future use of secondary batteries, which were then thought little of, has been more than justified by the extension of their use which has now come about; and with the great strides which are now being made in electrical work throughout the world they are being found to be more and more indispensable. It is now fully admitted that no domestic electric light installation is complete without them—that they are not only essential to our comfort and convenience, and for securing reliability and continuity of the light, but that great economy is effected by their use. With regard to the reliability of the light without them, doubtless some of you read lately in the newspapers the accounts of the consternation and inconvenience caused by the light going out at the Houses of Parliament three weeks ago, when little bits of candle had to be hunted up, and light improvised in every way. There was a case of a perfect installation, put up with the greatest care and with machinery in duplicate, and yet for the want of this one essential the light went out. This is, of course, a defect that the public will not put up with in the electric light, and unless accumulators are used we may be quite sure that the electric light will not extend in the way that we all know it is doing at present. The work, initiated at great cost by this Company, showing the utilisation of batteries for tramcars, is now about to bear fruit, and other developments must bring about the success which, I think, we must all feel the Company deserves, and bring increased profits to its coffers. I beg to second the resolution.

Mr. SCHOMBERG wished, on behalf of some shareholders, to ask one or two questions which, if the Chairman thought it prejudicial in the interests of the Company to answer, he might reasonably decline to do so. They saw in the balance-sheet that there was a profit of £35,937. Now, the question he had been asked to put was, what was the approximate net profit from the year's working? Possibly some of the amount might be from royalties and the sale of patents, and they would like to know exactly what was the amount of net profit on the working; because if they had a net profit of £35,000 odd in hand they could easily pay a dividend of 1s. a share, which would come to £7,000. He thought the shareholders ought to have some assurance from the Board that during the coming year there would be an interim dividend declared. With such a large balance as £13,500 supposed to be in hand, he considered that they were, after waiting patiently so long, fairly entitled to put something into their pockets. The next point that he would refer to was that they all knew the shares were dealt in largely on the London Stock Exchange, and he suggested whether it would not be advisable to have an official quotation of the shares there, which had not yet been secured. He referred with satisfaction to the fact that a very powerful gas company had been obliged to go to the E.P.S. Company for its apparatus to supply the electric light, and also to the circumstance that the specifications for the company's patents were so well drawn up that it was utterly impossible for any other company to supersede them.

Mr. ACKERY said it appeared to him that about £27,000 out of the £35,000 profits for the year was exceptional. He compared the estimated value of the patents last year with that of the current year, and asked whether the amount set down as net profit had been received in cash, or whether it was an amount carried into the account as the supposed additional value of the patents.

Mr. JOHN IRVING COURTENAY (Managing Director) read a letter from the auditors giving a detailed explanation of the entries of the balance-sheet. As to the question of an official quotation, asked by Mr. Schomberg, he could only only say that the Directors thoroughly agreed with that gentleman, and he was requested by some of the shareholders and the Board to interview Mr. Burdett, of the Stock Exchange, a year ago with a view to getting a quotation of the shares there. He hoped that the gentlemen for whom Mr. Schomberg spoke would bring some pressure to bear on Mr. Burdett to bring it about. The only reason given when he (the speaker) applied for it was that, although the shares were divided among 500 or 600 shareholders, a certain number of these shareholders held a very large interest in the Company. But he would say that the gentlemen who held a large stake in the concern did not do so for Stock Exchange purposes. At the same time, when the shares were spread among a large number of people he would be happy to renew their efforts to get a quotation. The question of Mr. Ackery had been answered by the report of the auditors which he had just read. There were obvious and judicious reasons why fuller details should not be published in view of the variety of interests of the Company. He wished to correct a mistaken view prevalent among the shareholders who spoke of the Company as a purely manufacturing company. That was an error. The Company had a variety of interests and different sources of income; and he was glad to say that all those sources of income had given them an increased revenue during the past year. They undertook not only the manufacture of secondary batteries, but also other kinds of electrical apparatus. Then they had the installation or contract department, and they all knew how well they had succeeded in respect to it—it was notorious

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throughout the country, and especially in London. Then they had another kind of interest represented by stock or shares, from which they would see that the Company had more than one string to its bow. At the same time, in all these branches of their business at home and abroad, they were face to face with an eager and pushing competition, and therefore, in the interests of the shareholders, it was advisable not to show exactly what they got from the separate branches. The whole amount had been lumped together, but such as their statement of accounts was, he would make bold to say, having gone through the accounts of many other leading trading and industrial companies in this country, that it was fuller than was usually given. In regard to an interim dividend, all he could say was that if they had had a sufficient working capital, they could have paid a dividend at once; but in that case they would have had to act upon one of two alternatives—either to diminish the cash working capital of the Company, and pay a dividend, or go to the shareholders and borrow money to carry on their enterprise. They thought they had acted wisely in deciding not to diminish the working capital. They hoped that with the same measure of success which had attended their working during the past year, they would realise a considerable amount of cash during the current twelve months, when it would be in the discretion of the Directors to say how and when it should be divided. As regarded the general business and prospects of the Company in what was called the "near" future, he could but say that in all respects they were eminently encouraging.

Mr. Ackery expressed his dissatisfaction with the explanation given, and said that he was as much in the dark as ever as to what was received for royalties and what from the net profit on the working of the year. It had been said that they had £13,500 in hand, and that a dividend should be given, but no doubt the Directors had adopted the most prudent course they could, and as far as he was concerned he should say that not a shilling should be divided until they had got rid of all their liabilities. But he did not think it was fair to the shareholders who did not look carefully into the figures to say that £35,000 had been made in profit last year, when a considerable proportion of it was merely an estimate of that which was the value of the patents in the future.

The Chairman pointed out that the auditors would not have passed the accounts if the state of the facts had been as Mr. Ackery suggested. That gentleman was totally wrong. The amount did not stand in cash, or in patents, or patent rights. At the same time it could have been made into cash if they had so desired.

The Managing Director said that the subject had been gone fully and carefully into, and the auditors insisted that it was the proper way, as a matter of book-keeping, of dealing with the amounts in question.

The Rev. Mr. Piggott asked that an approximate idea might be given of the Company's interest in the American Company.

The Chairman declined, for prudential reasons, to afford the information, and added that he did not see why the Company's accounts should be picked to pieces for stock-jobbing purposes.

A Shareholder thought that to mix up this Company's interests and trading accounts with those of an American undertaking was not the proper way to keep accounts.

The Managing Director said that he would be most gratified if their interests elsewhere should become so valuable that they would be able to pay a dividend to the shareholders if they made a loss on any branch of their business. He had the greatest confidence in the American interests, and they had put those interests down at a great deal less than their market value.

The Chairman said they knew exactly what some of the shareholders would like. But there was another point that they had taken no notice of, namely, the fact that £12,500 had been lent by the Directors, because they could not stand by and see the Company ruined for the sake of a few thousand pounds. The Directors had stood by it, not only with their brains and labour, but with their purses. The shareholders would therefore see that the £13,500 could not be divided whilst the Directors had that personal liability unsatisfied. Nobody would be more delighted than the Directors and himself if they could declare a 1s. dividend, because most of the shillings would have gone into their own pockets. But they thought that, as prudent men, they must always keep the Company in such a position that they would have sufficient cash to carry on its business comfortably, and to expand the sphere of its operations. The patents this year were much more valuable than they were a year ago.

Mr. Braithwaite thought they must all recognise the manner in which the Directors had made sacrifices in the interests of the Company, but he regretted that they did not say whether there had been any real profit made from the trading.

The Managing Director begged to call the attention of Mr. Braithwaite to the opening sentences of the Chairman's speech, where it was distinctly stated that they had made net profits from working.

The Chairman said that the Directors did not take any fees for three years, notwithstanding the laborious duties which they had had to perform.

The report was then adopted unanimously.

The Chairman then moved the re-election of the retiring Directors, Sir Daniel Cooper, Bart., and Colonel Fredk. Geo. Steuart, which was seconded by Mr. Allan, and agreed to.

The auditors, Messrs. Deloitte, Dever, Griffiths and Co., were subsequently reappointed.

On the motion of Mr. Schomberg, seconded by a Shareholder, a cordial vote of thanks was passed to the Chairman and the other Directors, which the former briefly acknowledged, remarking that the business this year gave them hopes that they would soon have another report to make showing a substantial profit.

The proceedings then terminated.

CITY NOTES.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 25th inst. amounted to £4,307.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company publish in our advertisement columns the numbers of 108 five per cent. debentures of £100 each (1880 issue), drawn for payment at par on 1st May next.

GLOBE TELEGRAPH AND TRUST COMPANY.—The directors at the board meeting held on 29th ult. declared the payment of an interim dividend, on and after the 19th proximo, of 3s. per share on the preference shares (less income tax), and of 1s. 6d. per share on the ordinary shares (income tax having been already deducted) for the quarter ended the 18th inst. The transfer books were ordered to be closed from the 12th to the 19th inst., both days inclusive.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 25th March were £3,420, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE STRAND ELECTRIC LIGHTING COMPANY (LIMITED)—Registered March 19 by Lewin and Co., 32, Southampton-street, Strand, W.C., with a capital of £30,000 divided into 6,000 shares of £5 each, with power to increase. Object, to generate and supply electricity, electric light, and electric power, for public or private purposes, in the Strand District and the parish of St. Martin's-in-the-Fields. The first subscribers are:—

	Shares.
J. Coles, engineer, 88, Tressilian-road, S.E.	1
S. C. Hannah, artist, 4, Wallerton-road, W.	1
P. G. Ebbutt, Lennard-road, Croydon	1
A. B. O. Paulsen, accountant, 51, Welbeck-street, W.	1
J. B. Verity, engineer, Weybridge	10
H. C. Hastings, clerk, 31, King-street, Covent Garden	1
J. V. Whitaker, publisher, Warwick-lane, E.C.	10

The first directors shall be J. B. Verity, J. S. C. Cunnington, and V. Whitaker. The remuneration of the chairman of the board of directors shall be £200 per annum, and of each other director other than the managing director (if any) £100 per annum.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. March 30.		Business Done Week Ending March 30. Highest.	Lowest.
Anglo-American	37,	38	37⅝	34
Do. Preferred	58,	59	57¾	55
Do. Deferred	15,	16	15½	14
Brazilian Submarine	10⅝,	10⅞	10 15-16	10⅞ xd.
Cuba	11½,	12	12	—
Do. Preference	18,	19	18½	–
Direct Spanish	2½,	3	2¾	2⅝
Do. Preference	7,	8	—	—
Direct United States Cable	9,	9½	9½	8¾
Eastern Telegraph	10¾,	11	10 15-16	10 11-16
Do. 6 per Cent. Preference	13,	14	14	13 11-16
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	11⅞,	12⅛	12 1-16	11⅞
German Union	8¼,	8¾	9⅛	— xd.
Globe Telegraph and Trust	5⅜,	5⅝	5 9-16	5
Do. Preference	12⅜,	12⅞	12 11-16	12⅝
Great Northern	13¾,	14	13 15-16	13⅞
Indo-European	35,	36	35¼	—
Reuter's	6¾,	7¼	6⅞	—
Submarine	180,	190	187⅝	—
West India and Panama	⅝,	⅞	¾	11-16
Do. 1st Preference	9½,	9¾	9⅝	9⅝
Western Brazilian	7,	7½	7 5-16	7⅛ xd.
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¾,	⅞	—	—
Oriental	3-16,	5-16	—	—
United Telephone	12¼,	12¾	12⅝	12 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	2 9-16	—
Do. (fully paid)	3¾,	4¼	4⅛	—
Swan	1⅜,	1⅝	1½	1⅝
Maxim Weston	3-16,	5-16	—	— xd.

MISCELLANEOUS.

Telegraph Construction	35½,	37½	36¾	36 xd.
India Rubber, Gutta Percha, and Telegraph Works	22,	23	23	22¾

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NOTES.

AWARDS.—Amongst the recipients of awards at the recent Building Trades Exhibition were Mr. Julius Sax and the Cluny Telephone Company.

SOUTH AMERICA.—The cable between Chorillos and Mollendo, announced in our last week's issue as being interrupted, has since been restored.

THE ELECTRIC LIGHTING ACT AMENDMENT BILL.—In the House of Lords, on Thursday last, the Electric Lighting Act (1882) Amendment Bill was read a third time and passed.

THE COMMERCIAL CABLE COMPANY. — Communication with America by this company's cable was restored early on the morning of the 2nd inst., after two days' interruption.

DOMESTIC LIGHTING.—The residence of Mr. E. Ashworth, at Staghills, near Bury, has been lit by water-power. The machine is driven by a water-wheel placed upon a stream at a distance of about 350 yards from the house, and charges a set of 27 accumulators.

THE COLONIAL CONFERENCE.—Among the questions put down for discussion by the Colonial Conference, which commenced its sittings on Monday last, No. 5 relates to cable communication between England and the colonies, and No. 6 to subsidies to existing cable companies.

COASTGUARDS AND THE TELEGRAPH.—In the House of Commons on Tuesday Lord G. Hamilton informed Colonel Laurie that proposals for placing certain coastguard stations in closer communication with main telegraph stations were now under consideration by the Admiralty.

THE SCOTT TORPEDO.—A torpedo has been brought out by Mr. Robert Scott, of Newcastle-on-Tyne, which is to be steered by electricity in a manner apparently very similar to that desired by Colonel Lay. The propulsion is effected by means of compressed air supplied through a hose pipe from the firing point.

HANDYBOOKS OF HANDICRAFTS.—We have received one of this series just published, "The Wood Turner's Handybook," a practical manual for workers at the lathe, by P. N. Hasluck. These useful little books are published by Crosby Lockwood and Co. at popular prices, and appear to be admirably adapted to the purpose they are intended to serve.

THE GERMAN PATENT OFFICE.—According to the official report of the German Patent Office, just published, the number of applications for patents rose from 5,949 in 1878 to 9,991 in 1886; but whilst in the former period only 25 per cent. of the applications were disallowed as not patentable, they increased in the latter to 60 per cent. In 1886, 4,008 patents were sealed, whilst 5,983 were disallowed.

ELECTRIC WHISTLE.—An electric whistle is easily made by fitting a small brass tube with suitable apertures so that it opens against the spring of a make-and-break of the usual electric hammer type. Such whistles are cheaper to make than electric bells, and may be made to give very melodious sounds. They have recently been introduced in France, and their use seems to be meeting with favour.

DR. TYNDALL.—Our readers will have already learned with regret that, on account of failing health, Dr. Tyndall has found it necessary to resign the position of Professor of Natural Philosophy at the Royal Institution, which he has now held for nearly thirty-four years. The last lecture delivered by him in the Theatre of the Royal Institution was in January, 1886, upon "Thomas Young, and the Wave Theory of Light."

IMPROVEMENTS IN THE TELEPHONE SERVICE IN AUSTRIA.—In the towns of Prague, Triest, Lemberg, Graz, Czernowitz, Pilsen, Reichenberg and Bielitz a new service has been introduced by which the subscribers to the exchanges can send and receive their telegrams by telephone, and this service is finding favour. The extra charge is 5 kreuzers, or 1d. for each telegram sent or received, and a large number of subscribers have already joined this service.

ELECTRICITY IN FARMING OPERATIONS.—At a meeting of the Farmers' Club, held at Nottingham, on Monday last, an address was delivered on the employment of electricity as a motive power in farming operations. It was pointed out that where water-power is available, and operations are conducted on a sufficiently large scale, electric motors can frequently be employed with considerable advantage. The installation on the Marquis of Salisbury's estate was described in detail.

THE NEWCASTLE JUBILEE EXHIBITION.—The *Newcastle Daily Chronicle*, of the 4th inst., devotes a couple of columns to a description of the electrical arrangements for the forthcoming Jubilee Exhibition in that town. We have already intimated that electricity will play an unusually important and extensive part in this exhibition, as in addition to the lighting a large amount of power transmission will be carried out. It is our intention shortly to give a special description of the whole of the arrangements.

ELECTRIC LIGHTING ON THE GLASGOW UNDERGROUND RAILWAY.—Some few months ago we described the system of train lighting devised by Mr. T. P. Carswell for use on the Glasgow Underground Railway, in which the current is taken up by a trailing collector. The experiments which have been carried out having proved satisfactory, the company has decided to adopt the system permanently for the whole of their trains upon the underground lines. The initial cost is estimated to amount to about £5,000.

THE "AIR SPACE" IN A DYNAMO.—Some time ago we suggested the desirability of finding, if possible, a more accurate term to indicate the space between the poles of the field-magnets and the iron in the armature of a dynamo, to which the French have given the name of "*entre-fer*." The American journals having expressed a similar opinion Dr. C. E. Woodman writes to the *Electrical World* of New York, suggesting that the word "annulus" would be a suitable term to use.

THE PRODUCTION OF OZONE.—Messrs. J. J. Thomson and R. Threlfall have carried out some experiments with a view of ascertaining whether ozone is produced in an electric field not quite strong enough to permit of the passage of the spark through the oxygen. Before passing into the chamber the gas was carefully dried and purified, and the issuing gas was tested with a most sensitive solution of potassium, iodide, and starch. Practically no ozone was found. It was further shown that when oxygen is dried to the least degree even the passage of a spark is unable to produce ozone.

THE HYDRO-ELECTRIC BATH.—Dr. Stein, of Frankfort-on-Main, has been making experiments upon the effects of hydro-electric baths—that is to say, baths constructed with a plate of metal at either end, the said plates being attached to the poles of a battery. The research is still in progress, but up to the present the only conclusion which has been definitely arrived at appears to be that "di-polar" baths are to be preferred to the "mono-polar" variety. In a "di-polar" bath the current enters and leaves entirely through the water. In a "mono-polar" bath, on the contrary, the circuit is completed through some portion of the body which remains above the water.

OVERHEAD WIRE ACCIDENT.—In reference to the Note on this subject in our last issue, Mr. MacIver, the secretary and

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manager of the Lancashire and Cheshire Telephonic Exchange Company, writes us as follows:—"In course of your short paragraph you say that a wire of ours, when falling to the ground, 'looped around the neck of a cabman, dragging him off his seat, and landing him in the street.' The wire in question was simply a 'stay' which was being taken down very carefully by our workmen. A passing cab nearly ran into the 'stay' as it was being lowered with ropes, but, so far as our information goes—and we have made a full inquiry—the cabman was not even touched."

FIELD TELEGRAPH TRAINS.—We learn from *Engineering* that the Atlas Engineering Works, Södertelje, Sweden, have just completed, for the Portuguese Government, a number of carriages, six of which constitute a complete field telegraph train. One carriage makes the telegraph station, with convenient accommodation for despatching messages; the next is a van which is able to hold 150 somewhat slender poles; the third carriage is intended to carry a supply of wire—11,000 metres four twisted wire in eleven rolls; next comes a carriage with all the requisite tools, and the last two are for various stores. The carriages are made partly of ash and partly of Swedish pine; all the woodwork is varnished. The wheels are of steel, and are made under Wersén's patent.

PROF. BELL ON THE TELEPHONE.—Prof. A. G. Bell recently delivered an address on the telephone and photophone to the students of the Cornell University. According to the professor's view, it is a mistake to consider the telephone as an instrument of great delicacy. The wonder is that we can hear speech with it all. It is the marvellous sensitiveness of the ear which alone makes the telephone of any practical avail. Without disputing this point with the professor it is obvious that the extreme sensibility of the ear after all only enables it to detect what the disc of the telephone is able to utter; and the less the amplitude of the vibration the more difficult is it to comprehend how the metal plate can still respond to all the unimaginable complexities of the sound waves.

THE PASSAGE OF AN ELECTRIC CURRENT THROUGH AIR. In the *Beiblatter der Physik* the following singular experiment is described by J. Borgmann. One terminal of a delicate reflecting galvanometer is connected with the earth, and the other with a platinum wire, which is placed in the flame of an insulated spirit lamp. At a distance of 1½ metres from this lamp is an ordinary Bunsen burner, which is connected with the conductor of a Holtz machine; the other conductor of the machine is put to earth. The spirit lamp being lighted care is taken that no deflection is caused by thermo-electric currents. The discs of the induction machine are then rotated, when a current is at once indicated upon the galvanometer, and the deflection remains constant so long as the machine works at a uniform rate. If the Bunsen burner is connected with the other conductor of the machine, the direction of the current is reversed.

ELECTRIC LIGHTS FOR RAILWAY CARRIAGES.—Experiments are shortly to made with a view to the introduction of the electric light into the railway carriages in India. Owing to the large distances to be traversed in India, night journeys are a necessity; in fact, by reason of the comparative coolness of night travelling, many people prefer trains which run after dark. The carriages are now lighted by the old-fashioned oil lamps, which give only a dim light, and often no light at all when the railway servants omit to trim them. The uselessness of the oil lamp for reading purposes is not its only drawback. There is always a certain amount of danger from its bursting and setting fire to the carriage. A case of this kind actually occurred a few weeks ago on a line near Bombay. Fortunately no injury was caused to the occupants of the carriage; but some damage was done to their personal effects.—*Industries.*

THE LATE MR. GEORGE BLEWETT.—We regret to have to announce the death of Mr. George Blewett, A.S.T.E., and Superintending Engineer of the Postal Telegraphs, which took place somewhat suddenly at Manchester, on the 28th March last. The body was interred at St. Sepulchre's Cemetery, Oxford. The sincere respect which was felt for Mr. Blewett was made evident at the funeral by the numerous wreaths which were placed on the coffin. In addition to a large number from personal friends, wreaths were taken from the Engineer-in-Chief's office, the Controller of Stores office, the Manchester Central Telegraph Office, and the engineer's staff of the North-Western Division. The various departments of the telegraph service were represented by Major C. F. C. Beresford, R.E., J. H. Cordeaux, Esq., E. Ashton, Esq., and J. H. Knight, Esq., of London; J. Jenkin, Esq., Cambridge; J. Doherty, Esq., Manchester; J. Gavey, Esq., Cardiff; F. E. Evans, Esq., Birmingham; the local engineering staff by Mr. J. W. Woods, and the local post office staff by Mr. F. Porthury.

OVERTIME IN PROVINCIAL TELEGRAPH OFFICES.—On Monday last Mr. Broadhurst asked the Postmaster-General whether it was a fact that the telegraphists in London were paid overtime for the work they perform between midnight on Saturday and midnight on Sunday; and, if so, whether he would extend this proper recognition of exceptional labour to the provincial telegraphists? Mr. Raikes, in reply to the hon. member, said he had to state that a similar question was put to the right hon. gentleman, the member for Wolverhampton, in March, 1886, and he was disposed to concur with the reply which that gentleman then gave. The arrangements in London differ from those in the country, and wages in London do not include remuneration for service on Sundays, which is, when performed, paid for separately. The question of pay for Sunday work in the provinces was carefully considered at the date of the re-organisation of 1881, and the scale of weekly wages was fixed so as to cover two hours' work on Sundays. Applications have been received by three successive Postmasters-General for further pay in addition to that given on Sundays, and have been refused by each. He was not prepared to depart from that decision.

AIR PUMPS.—Some attention is being given to the possibility of abandoning the use of mercury pumps in the manufacture of incandescent lamps in favour of pumps of purely mechanical action. If a mechanical pump can be relied upon to give an equally good vacuum, it will generally be preferred to a mercury pump on account of its more substantial structure, and the consequent possibility of working at higher speed; besides which the use of mercury is expensive and objectionable in other ways. In America a mechanical pump has recently been brought out by Mr. A. B. Worth, in which the difficulty of lifting the valves as very low pressures are reached is overcome in a simple and ingenious manner. The pump, which is driven by steam power at a high speed, consists of a pair of cylinders, containing pistons and valves of the ordinary type, except that each valve is provided with a small iron disc which forms the armature of an electro-magnet by means of which it can be lifted. The current is provided by a small dynamo connected with the pump, and the valves are operated by properly adjusted commutators. The two cylinders are at first set to exhaust side by side, by which low pressures are rapidly attained, while at a later stage one of

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them exhausts into the other, and in this way a very fine vacuum is produced.

THE BELL TELEPHONE PATENT IN AUSTRIA.—Herr R. H. Krause, of the Austrian Telephone Company, writes as follows : "The notice in your issue of the 18th inst., taken from the *Electro-Techniker*, just to hand, is misleading. It is true that the first action for annulment of the patent was not quite successful, the decision being that, whilst the company's action was pending, another action had been decided, by which three important clauses of the patent had been cancelled, and therefore the company's action was dismissed. The principal gain was that all telephones made without a soft iron pole were rendered free. Another much more important action, or, rather, petition for annulment, was then instituted, and is still pending, and can hardly be decided under a year. There are also about six more pending brought by other parties. Apart, however, from these, the Ministry of Commerce, as the patent authority, has recently decided that the use of telephones by an exchange is no infringement of the Austrian patent law. This law prohibits the making in Austria, the importation for purposes of sale, the sale and the exhibition for purposes of sale. The Ministry has decided that as the companies only use the telephone and buy or import for their *own* use, they are not infringing the patent, and thus your notice is liable to be misconstrued. That it represents the wishes of the patentees is clear, but it is not a fact. It may interest some of your readers to hear that for nearly seven years nobody knew in Austria who was really the owner of the patent, there having been disputes about the rights granted for its sole use to an Austrian firm."

THE D'ARSONVAL GALVANOMETER.—It is somewhat to be regretted that the merits of the D'Arsonval galvanometer should be as yet so little appreciated in this country. In France the use of this instrument is very general, and it has been employed with advantage in several investigations involving laborious work. The instrument was designed originally with a view to obtain a sensitive mirror galvanometer which should be influenced as little as possible by variations in the external magnetic field. We have recently had the pleasure of examining a D'Arsonval in the laboratory of a well-known amateur; with the scale at four feet from the mirror, a single Leclanché produced a deflection of about 15 inches through a resistance of half a megohm, yet the spot remained motionless while a large steel magnet was moved in the neighbourhood, the current still traversing the coil. In this particular instrument the dead-beat qualities of the D'Arsonval type had, however, been sacrificed to some extent, with a view of obtaining increased sensitiveness. Another point which is still more strongly in favour of the apparatus is its low cost. At a rough guess we should be inclined to think that the instrument could easily be made at less than one-third the cost of an ordinary reflecting galvanometer of equal sensitiveness. There is, however, one drawback attending its use; for the purposes of a ballistic galvanometer it is very little good. It might, perhaps, be employed with a condenser of very small capacity. Condenser discharges play such an important part in testing, and can so seldom be combined with zero readings, that a galvanometer which does not readily lend itself to this class of work must be admitted to labour under a disadvantage. In all other respects the instrument is one which will certainly render great service in the future, and which is peculiarly suited to the requirements of dynamo and motor tests.

PASSAGE OF ELECTRIC DISCHARGE THROUGH PURE NITROGEN.—Messrs. J. J. Thomson and R. Threlfall have observed that when a succession of electric sparks is sent through a sealed discharge tube containing nitrogen at a pressure less than 20 mm. of mercury, a permanent diminution of the nitrogen takes place, which ultimately reaches a maximum of 8 to 12 per cent. of the original volume if the pressure be 8 mm., but only 2 to 3 per cent. with a pressure of 16 mm. A considerable time is required before this maximum value is attained, and the ratio of this diminution to the original volume is independent of the volume of the discharge tube, the extent of its surface, and the substance of the electrode, whether platinum or aluminium. If the tube is maintained at a temperature of over 100deg. for several hours, the gas regains its original volume. The apparatus is described in full, as also the method used for the preparation of the nitrogen, the determination of the quantity of oxygen contained in the gas and the elimination of hydrogen from the electrodes as evidenced by spectroscopic examination. It was proved that the gas used contained less than 1 part in 800 of oxygen, whilst the contraction observed would require the presence of 15 per cent. of hydrogen if this gas combined with the nitrogen to form ammonia, whereas only the minutest traces of hydrogen could be detected by means of the spectroscope. The authors incline to the hypothesis that an allotropic modification of nitrogen is produced by the sparking, and the phenomena of the contraction of volume and expansion on heating are analogous to those observed in the case of ozone. It is further noticed that when the discharge passes through nitrogen, whose pressure has been diminished by sparking, it shows a greater tendency to produce a beautiful golden colour than when it passes through a tube recently filled. No attempts have thus far been made to ascertain the chemical properties of this modified gas. [Note.—Mr. G. S. Johnson, in a pamphlet entitled "Elementary Nitrogen," has described the production of an allotropic modification of this gas under conditions somewhat similar to those mentioned above].—*Jour. Chem. Soc.*

LIGHTING OF A FRENCH YACHT.—A SINGULAR INSTALLATION.—The yacht "Isle de Jersey," of Cherbourg, has recently been fitted with an installation of electric light, consisting of one projector of 1,000 carcels, 200 Gimé incandescent lamps of 25 candle-power, and two of 100 candle-power each, the latter being used for the side lights. Some description of the Gimé lamp, which is a new and interesting type, will be found in another column. The dynamos are made by Ackermann, and are driven by a couple of high-speed "Farrey" engines of 25 horse-power. The machines give 900 volts at their terminals, and the 200 lamps are divided into 20 separate circuits, 10 lamps being connected in series upon each. When the projector is brought into use it is necessary to employ both dynamos together, and only 100 incandescents can then be run at the same time. Altogether, it will be seen that this is an installation of quite a remarkable character, and differs very widely from the ordinary run of ship lighting installations, or jobs, as a friend of ours prefers to call them. It is a little difficult, perhaps, to understand what can have been the motive which has led to the use of a multiple series high tension system (especially with lamps of 90 volts) within the narrow limits of a yacht. We are inclined, moreover, to think that, not merely in this case, but in the majority of ship lighting jobs, a mistake has been made in using lamps of such high candle-power. In the saloon the candle-power to be used is chiefly a matter of taste, and will make little or no difference in the cost of the installation; but for the cabins, or state-rooms as they are called on the liners, lamps of 10 candle-power are amply sufficient. Some time ago, when (following the precedent of oil-lighting days) it was customary to place the switch outside, leaving the inmate of

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the cabin entirely at the mercy of the stewards in the matter of light; it was also a frequent arrangement to provide a single lamp between every two adjacent state rooms. It is now found perfectly safe to place the switch at the disposal of the passenger, and the latter would in all probability find no ground for complaint if he were provided with a cabin lamp of half the usual candle-power.

ELECTROLYTIC POLARISATION PRODUCED BY SMALL ELECTROMOTIVE FORCES. By C. FROMME (*Ann. Phys. Chem.*).—The polarisation of platinum plates in dilute sulphuric acid was measured during the flow of the polarising current, which was always so small as to produce no visible evolution of gases. Two forms of electrolytic cell were employed, the first open, containing two platinum electrodes in cells, joined by a tube containing a third, and a second form in which there were four equidistant electrodes contained in a glass tube. The acid employed varied in strength from 1 per cent. to 3 per cent., the amount of dilution not being found to produce any observable result. With the latter form of cell the two middle electrodes were joined to the battery through a variable resistance, the two outer plates being for the purpose of measuring the potentials of the others by connection with a quadrant electrometer. In the first set of experiments it was found that the maximum polarisation had occurred by the time the electrometer could be read, and the difference of potential was nearly equal to that obtained by joining the battery directly to the electrometer. Experiments with the open voltameter led to the conclusion that the difference of potentials between the plates remained nearly constant from the instant of making the current, but that the polarisation of the oxygen plate continuously *increased*, whilst that of the hydrogen plate *decreased*. In a voltameter free from air, the changes were similar, but in an opposite direction. The influence of a previous polarisation of the electrodes was examined, the battery being joined first in the same direction, and secondly in the reverse direction to that of the former current, and also the effect of polarisation of only one of the electrodes, this being effected by introducing temporarily a third electrode, and using it as an anode or cathode as required. By raising an electrode gradually out of the liquid, the effect of change of area was examined, and it was found that if either anode or cathode were raised so as to lessen its area of immersion, its polarisation was increased at the expense of the other. Many other experiments were made, but without leading to any general conclusions, the author intending to extend the investigation, using gold and silver electrodes.—*Journal Chem. Soc.*

HOWELL'S CARBON CUTTING MACHINE.—What is likely to prove an invention of great practical value and economy in the use of battery cells is now on its trial at the works of Mr. T. J. Howell, or rather of the limited company of which he is the manager, at Hamilton-road, Grove-road, Mile End. This is a new and speedy process of reducing retort carbon to the dimensions required for use in cells. By the old method it is well known that the pieces of carbon as they left the retort had to be chiselled down and then ground to the requisite size and smoothness, involving a great amount of labour and no little waste of the material itself. Mr. Howell, however, has devised a machine which obviates to a great extent both these drawbacks. The irregular blocks of carbon are first placed in a wooden frame and embedded in layers of cement, in which condition they remain for about a week, by which time the whole becomes solidly welded together. The mass is then operated upon by his patent carbon cutting machine, which can cut thousands of carbon plates at one process from one eighth of an inch and upwards in thickness, and of any desired length or breadth. The action of this machine is very similar to that of granite and marble cutting machines. In the course of its reciprocating motion it does not vary in its rise or fall or in the stroke, no matter what the depth of the material it may have to cut through. This circumstance is due to the manner in which the machine is suspended to the overhead gearing. The grit or sand and water employed as the cutting medium are acted upon by the blades of the machines, of which there are between fifty and sixty in the one now at work, with greater and more uniform effect. After the work of cutting is finished the pieces of carbon are made into different sizes and shapes and ground down till they have a smooth surface upon a revolving wheel. Gas retort carbon has always been more highly esteemed by electricians on account of its great durability and high electrical conductivity than the compressed form of the material; but its excessive hardness has hitherto rendered its manufacture into wedges of the proper size and shape a work of considerable difficulty and expense. But after witnessing the surprising rapidity and neatness with which this machine does its work, it seems reasonable to expect that gas carbon will now be as readily available as the moulded or compressed forms.

LIVERPOOL.—Milner's Safe Company, Liverpool, have recently completed the lighting of their new erecting shop, and also of the adjoining machine and fitting shop, with the electric light, the contract having been placed in the hands of the Gülcher Electric Light and Power Company. The large erecting shop, which is 310ft. long by 35ft. wide, is lit by six 3,000 candle-power arc lamps placed high up in the roof above the traveller, and the machine and fitting shop with seven 2,000 candle-power arc lamps placed in the company's "factory lantern," which is fitted with a large reflector and diffusion glass, so that it can be used in places where there is little light After a trial of over two months this method of lighting has proved very satisfactory. The installation was erected to the specification of Mr. F. B. Welsh, of Manchester, consulting engineer to Milner's Safe Company. The plant erected consists of one 20-unit Gülcher compound dynamo, giving an E.M.F. of 65 volts at the terminals at a speed of 600 revo lutions per minute. The dynamo gives the above output without the slightest sign of sparking on the commutator, and runs perfectly cool when carrying its full load; the machine being placed on a sliding cast-iron bed plate, any slack of the belt is readily taken up. A very substantial six-circuit main switch with cut-outs to each circuit is provided, and is also fitted with a negative terminal bar, the whole being mounted on a slate slab 2ft. by 3ft.; from this point the current is led by two main circuits, consisting of 14/15, capable of tapering to 19/17 and 19/19 at the ends. This taper cable was specially manufactured by Messrs. W. T. Glover and Co., all the tapering being done before insulating, the joints being far neater and more reliable than they could possibly be if the ordinary method of joining had been adopted. The engine room and manager's office are lighted with nine 16 candle-power incandescent lamps. In the painting shop a special portable lamp with a wrought-iron stand is used; the lamp is constructed so that it can be held in one hand whilst painting with the the other, if the work is very intricate, and a light required close to it, but for ordinary work it is placed in the stand. This arrangement has been found most convenient for painting inside large safes or strong rooms, saving all the inconvenience of oil lamps or candles, besides being more economical. The motive power is obtained from the new engine put down by Messrs. Marshall, Sons, and Co., of Gainsboro', which is capable of indicating up to 120 horse-power.

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WILLIAM HENRY PREECE.

We have the pleasure this week of presenting to subscribers and readers of *The Electrician* a fine steel engraved portrait of Mr. W. H. Preece, the well known head of the electrical department of the British Postal Telegraphs. Mr. Preece is a native of North Wales, having been born near Carnarvon in 1834. After receiving his education at King's College, London, he entered the office of Mr. Edwin Clark, C.E., in 1852, and in the following year joined the service of the Electric and International Telegraph Company. Rising rapidly in this company, he became Superintendent of its Southern Division in 1856, and held a similar position for the L. and S. W. Railway from the year 1860, as well as that of Engineer to the Channel Islands Telegraph Company in 1858. On the transfer of the Telegraphs to the State in 1870 he was appointed one of the Divisional Engineers, from which position he rose to that of Electrician for the whole service in 1877, an appointment which he has held to the present time.

The remarkable gifts of Mr. Preece as a lecturer on science have brought him prominently before the general public, who crowd to the halls of the Society of Arts or the Royal Institution whenever he is discoursing on some of the electrical topics of the hour, or explaining the mysteries of some inventive marvel. His original researches for the furtherance of the special science which he cultivates, and his various practical inventions, have also won the suffrage of his fellow workers, and given him a leading place amongst them. Moreover, the active interest which he manifests in all that relates to his profession, and the genial good humour of the man, are of themselves enough to make him popular with electricians. Mr. Preece is also consulting electrician to the British Colonial Government. He is a Fellow of the Royal Society and a Member of the Council of the Institution of Civil Engineers, to which he was elected in 1859. He was president of the Society of Telegraph-Engineers for the year 1880, and he is a Member of the Physical Society, Meteorological Society, the Royal Institution, the British Association, and the Society of Arts. Mr. Preece is the inventor of a new method of duplex telegraphy, patented in 1855; a new mode of "terminating" wires (1858); working miniature signals by electricity to assimilate electric signals with outdoor signals on railways (1862); the application of electricity to domestic telegraph purposes (1864); the application of electricity for signalling between different parts of a train in motion (1861); locking signals on railways by means of electricity (1865); improvements in railway signalling to counteract the effects of lightning (1873); a new telephone (1878); improved communication between passengers and guard (1882).

He is a joint author with Mr. Sievewright of a "Text-book of Telegraphy;" has edited several works, and written many papers for the scientific press, among which latter the following may be mentioned:—

Before the British Association: "The Telephone," "Recent Progress in Telegraphy," "Lightning Protectors," "Recent Progress in Telephony," "Telegraphic Inter-communication," "Domestic Electric Lighting," "On the Watt and Horse-power," "On the Use of Secondary Batteries for Telegraphy," "On the Law of Incandescence and its Relation to Current," "On the Relative Merits of Copper and Iron" (1885); "On the Strength of Telegraph Poles" (1885). Before the Society of Arts: "On the Phonograph," "Cantor Lectures," 1879, "Recent Advances in Telegraphy," "Recent Advances in Electric Lighting," "Electric Lighting at the Paris Exhibition," "Electrical Exhibitions," "On the Progress of Electric Lighting," "Electric Lighting in America." Before the Royal Society: "Studies in Acoustics" (jointly with Mr. Stroh), "On Some Thermal Effects of Electric Currents," "On the Conversion of Radiant Energy into Sonorous Vibrations," "The Effects of Temperature on the Electromotive Force and Resistance of Batteries," "On a New Standard of Illumination and the Measurement of Light," "On the Heating Effects of Currents" (1884), "The Edison Effect on Glow Lamps" (1885), "On Secondary Batteries" (1887). Before the Society of Telegraph-Engineers: "On a New Telegraph Wire Gauge," "Telegraphy—Its Rise and Progress in England," "On the Advantages of Scientific Education," "On Lightning and Lightning Conductors," "On the Block System of Working on Railways," "On Shunts, and their Application to Electrometric and Telegraphic Purposes," "On the Measurement of Currents," "On the Phonograph," "On the Connection between Sound and Electricity," "On Winding Electro-Magnets," "On the Durability of Iron Wire," "On Radiophony," "On the Electrical Congresses of Paris" (1884), "A Visit to Canada and the United States" (1885), "Long Distance Telephony" (1886)." Before the Physical Society: "On Some Physical Points Connected with the Telephone," "The Phonograph." For the Royal Institution: "On the Applications of Electricity to the Protection of Life on Railways," "The Telephone," "On Duplex and Quadruplex Telegraphy," "On Wheatstone's Telegraphic Achievements." For the Institution of Civil Engineers: "On the Maintenance and Durability of Submarine Cables in Shallow Waters," "On Railway Telegraphs and the Application of Electricity to the Signalling and Working of Trains," "On the Best Means of Communicating between the Passengers, Guards, and Drivers of Trains in Motion," "On the Progress of Telegraphy" (lecture), "On Electrical Conductors."

It is not too much to say that owing to his exertions the scientific branch of the Telegraph Department of our Post Office has become a pattern to the world. The capacity of wires for the transmission of messages has been quadrupled; the quality of the apparatus used has reached well-nigh perfection; scientific methods of the strictest accuracy have been applied to every branch; and a healthful spirit of striving after technical superiority introduced among the staff—a spirit exceptional in Government Departments, and doubtless due to his early training in commercial enterprises.

THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 435.)

Let

E = Total E.M.F. in armature (volts).
C = Total current in armature (amperes).
R = Radius of core (inches).
S = Total surface of core (square inches).
N = Number of longitudinal wires around the outside of the armature.
l = Number of layers on the armature, counted on the inside if annular.
A = Sectional area of single conductor.
w = Width of conductor (inches).
β = Total depth of conductors in respect to radius, counted on the inside if annular.
μ = Coefficient representing ratio of copper to linear space occupied.
d = Total depth of copper $= \mu \beta$ R.
P = Number of poles in field-magnets.
ρ = Number of watts converted into heat per square inch of core surface.
γ = Coefficient representing ratio of iron to sectional space occupied.
p = Total depth of core in respect to radius.
q = Total length of core in respect to radius.
α = Total cross section of core (inches).
a = Cross section of iron in core $= \gamma \alpha$.
n = Number of revolutions per minute.
r_a = Resistance of armature measured across the brushes.

We suppose the current and resistance such that the watts dissipated $= \rho$ S. Then, from geometrical considerations, it is clear that

$$S = 2\pi R \,.\, qR + 2\{\pi R^2 - \pi(1-p)^2 R^2\} + 2\pi(1-p) R \,.\, qR,$$
$$= 2\pi R^2\{2(q+p) - qp - p^2\}, \text{ and}$$

$$r_a = \frac{2\pi R^2 \rho}{C^2}\{2(q+p) - qp - p^2\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Also $$r_a = \frac{\text{Length of wire in inches}}{1,620,000 \, P^2 A}$$

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1,620,000 being the number of inches of copper, 1 square inch in section making one ohm at the average working temperature.

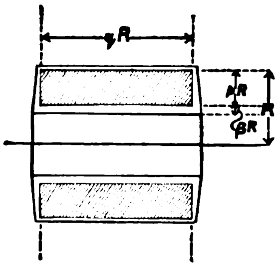

FIG. 6.

With rectangular wire

$$A = \frac{wd}{l}$$

$$w = \frac{2\pi l \mu \{(1-p)R - \beta R\}}{N}$$

$$= \frac{2\pi l \mu R(1-p-\beta)}{N}$$

$d = \mu \beta R$;

whence $$A = \frac{2\pi \mu^2 R^2 \beta (1-p-\beta)}{N}.$$

Length of wire $= N\{2R(q+\beta) + 2R(p+\beta)\}$

$$= 2NR(q+p+2\beta),$$

thus, $$r_a = \frac{N^2(q+p+2\beta)}{1{,}620{,}000\,\pi \mu^2 P^2 R \beta (1-p-\beta)} \quad . \quad . \quad (2)$$

Equating the two values of r_a we get,

$$R^3 = \frac{C^2 N^2 (q+p+2\beta)}{3{,}240{,}000\,\pi^2 \mu^2 P^2 \rho \beta (1-p-\beta)\{2(q+p) - qp - p^2\}} \quad . \quad . \quad (3)$$

We have seen that

$$E = 2Ma \,.\, N \,.\, n\, 10^{-6},$$

but $$a = \gamma \alpha \text{ and } \alpha = pqR^2$$

$$\therefore a = pq\gamma R^2,$$

and $$E = 2Mpq\gamma R^2 \,.\, N \,.\, n \,.\, 10^{-6}.$$

Taking out N we have

$$N = \frac{E \,.\, 10^6}{2Mpq\gamma n R^2},$$

square both sides,

$$N^2 = \frac{E^2 \,.\, 10^{12}}{4(Mpq\gamma n R^2)^2},$$

substituting in (3)

$$R^7 = \frac{E^2 C^2 (q+p+2\beta) \,.\, 10^{12}}{1296 \times 10^4 (\pi \mu p q \gamma n P M)^2 \rho \beta (1-p-\beta)\{2(q+p) - qp - p^2\}}$$

whence finally

$$R = 3{\cdot}6 \left[\frac{E^2 C^2 (q+p+2\beta)}{\rho \beta (\mu p q \gamma n P M)^2 (1-p-\beta)\{2(q+p) - qp - p^2\}}\right]^{\frac{1}{7}} (4)$$

We have now obtained expressions for the radius, number of wires counted all round the armature, and section of copper in terms of our premised proportions.

In an article in *The Electrician*, Vol. XVI., the author showed that, in order to obtain the maximum activity from a given weight of iron in the armature, the coefficient p should be as large as possible; whilst to expose a large surface to the field, and to minimise the length of conductor per volt, the section of the core should be square. Unfortunately, the combination of a square core with great radial depth involves difficulties of a practical nature in the winding, which, in order to fill the space economically, has to be very much deeper on the interior than on the exterior surface of the ring; the reduction in magnetic resistance by extending the polar extremities to the side faces of the core is also effected, as we shall presently see, at the cost of increased leakage in the magnetic lines; the advantage of such a construction is thereby laid open to some question.

We shall not, therefore, attempt at present to fix any definite proportions for the core, but will leave these coefficients to be valued by the actual practice of each maker. β is also an arbitrary and widely varying coefficient. No doubt there are important considerations which should assist us in fixing its proper value, at least within comparatively narrow limits. Much depends on the clearance between the wire and the magnet poles deemed necessary to practical safety; it is a point of considerable importance, and involves several issues upon which we shall be better able to comment later on. The coefficient μ is variable for different gauges of wire; a curve from which sufficiently accurate values may be taken for the usual sizes are given in Fig. 7*. It should be remarked that the formula $\mu = \frac{\text{Thickness}}{\text{Thickness} + {\cdot}05}$ is based on the assumption that both ends of a coil are made to finish outside so as to

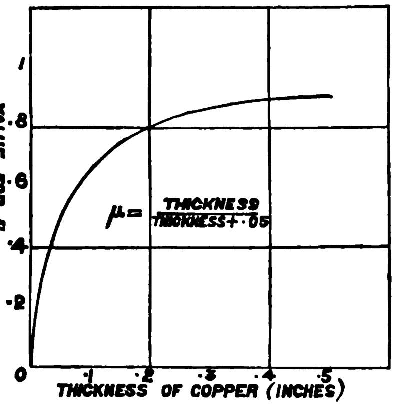

FIG. 7.

use the least possible space in winding. γ depends, of course, on the construction of the core, and is easily determined by the weight. The author finds ·65 to be a fair average value for cores built up of rectangular wire, and ·8 for hoop iron. The maximum possible value for the magnetic density M is given by Mr. Kapp as 25 for charcoal iron wire or soft hoop iron, and 22 for charcoal washers.† The highest induction practically attainable may therefore be taken as 20 to 23.

The value of ρ for drum armatures and cylinder rings may be taken from ·8 to 1; for square cores of great radial depth, where $p = {\cdot}5$ to ·7, it may be increased to 1·1, and in disc machines of the multipolar type to 1·2. The ascending values for ρ here given are indicative of the ventilating properties of the several designs.

The fact that in multipolar machines ρ can be taken at a higher value than in other types considerably modifies any adverse theoretical conclusions regarding them; indeed, as we shall see in due course, in many respects they exhibit distinct advantages over bipolar machines.

The formulæ derived above may, of course, be very much simplified in practical application to any single type; thus, for instance, all the values on the right hand side of (4) are constant with the exception of E C μ and n. We may therefore

write $$R = B\left(\frac{EC}{\mu n}\right)^{\frac{2}{7}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Where B equals 3·6 into the 7th root of the constant factors.

In the same manner the other equations will take the form

$$N = D\frac{E}{nR^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$A = F\frac{(\mu R)^2}{N} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

and $$r_a = GR^3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

* Strictly speaking the coefficient μ should be duplicated and two curves should be employed from which to take the values, one being for the thickness of the wire and the other for the width. The coefficients would then always appear in the formula as a product $(\mu\mu)$, instead of μ^2. In practice, however, the one formula $\mu = \frac{\text{Thickness}}{\text{Thickness} + {\cdot}05}$ is sufficiently accurate for both values, and a simplification is thus effected.

† Quite recently Prof. J. A. Ewing and Mr. William Low have made some interesting experiments with a view to determine the maximum induction of which soft iron is capable. Their highest figure reduced to the system here used is 35·6 lines per square inch. See *Industries*, Vol. 2, No. 40.

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The foregoing calculations are really only strictly accurate when dealing with armatures in which the copper depth is equal on the inside and outside of the ring. In applying them to machines in which a greater depth is allowed on the interior than on the exterior we must introduce another co-efficient t to denote the depth of outside conductor with respect to the radius; the expression for the length of wire will then be $2NR(q+p+\beta+t)$, the term within the brackets being carried throughout the calculation in place of $(q+p+2\beta)$.

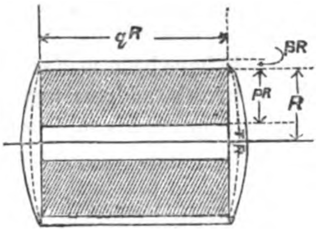


FIG. 8.

In the case of drum armatures some modification is necessary in the whole treatment. Referring to Fig. 8 we may take

$$S = 2\pi R \cdot qR + 2\pi R^2,$$
$$= 2\pi R^2 (q+1),$$
$$r_a = \frac{2\pi\rho R^2 (q+1)}{C^2} \quad \ldots\ldots \quad (1a)$$
$$A = \frac{w\mu\beta R}{l},$$
$$w = \frac{2\pi R\mu l}{N};$$

whence
$$A = \frac{2\pi\beta\mu^2 R^2}{N}.$$

The wire in each coil would not be properly taken as a rectangular length, because the crossing at the ends leads to an egg-shaped figure. We must therefore be content to express the mean length of the end wires as a linear function of the radius. We shall thus write—

Length of wire $= N\{2(qR+\beta R) + 2\tau R\}$,
$= 2NR(q+\beta+\tau)$,

also
$$r_a = \frac{N^2(q+\beta+\tau)}{1{,}620{,}000\,\pi\beta\mu^2 P^2 R} \quad \ldots\ldots \quad (2a)$$

We now get
$$R^3 = \frac{C^2 N^2 (q+\beta+\tau)}{3{,}240{,}000\,\pi^2\mu^2 P^2 \rho\beta(q+1)} \quad \ldots\ldots \quad (3a)$$

N remains as before $= \dfrac{E \cdot 10^6}{2Mpq\gamma nR^2}$

$$R^7 = \frac{E^2 C^2 (q+\beta+\tau) \cdot 10^{12}}{1296 \times 10^4 (\pi\mu Ppq\gamma nM)^2 \rho\beta(q+1)}$$

$$R = 3\cdot 6 \left[\frac{E^2 C^2 (q+\beta+\tau)}{\rho\beta(q+1)(\pi\mu pq\gamma nPM)^2}\right]^{\frac{1}{7}} \quad . \quad (4a)$$

The value of the new coefficient τ is, of course, readily determined upon commencing any particular designs, but it is better to leave it here in a general form.

In practice these expressions will reduce as before to

$$R = B_1 \left(\frac{EC}{\mu n}\right)^{\frac{2}{7}} \quad \ldots\ldots \quad (5a)$$
$$N = D_1 \frac{E}{nR^2} \quad \ldots\ldots \quad (6a)$$
$$A = F_1 \frac{(\mu R)^2}{N} \quad \ldots\ldots \quad (7a)$$
$$r_a = G_1 R^2 \quad \ldots\ldots \quad (8a)$$

It is often convenient to have equations 5 and 5_a in terms of the peripheral velocity instead of revolutions per minute. For this purpose we substitute $\dfrac{12V}{2\pi R}$ for n where V = peripheral velocity in feet per minute; thus

$$R = B\left(\frac{2\pi ECR}{12\mu V}\right)^{\frac{2}{7}}$$
$$= B\left(\frac{\pi}{6}\right)^{\frac{2}{7}}\left(\frac{ECR}{\mu V}\right)^{\frac{2}{7}}$$
$$R^{\frac{5}{7}} = \cdot 831\,B\left(\frac{EC}{\mu V}\right)^{\frac{2}{7}},$$
$$R = \cdot 77\,B^{\frac{7}{5}}\left(\frac{EC}{\mu V}\right)^{\frac{2}{5}} \quad \ldots\ldots \quad (9)$$

It is instructive to note from the foregoing results that in a dynamo the output cannot be said to vary as any stated power of the linear dimensions, without taking the speed and coefficient of insulation into consideration. What may be correctly said is that the output

$\propto$ (μ × angular velocity)$^{\frac{2}{7}}$ (Linear dimensions)$^{\frac{7}{2}}$,

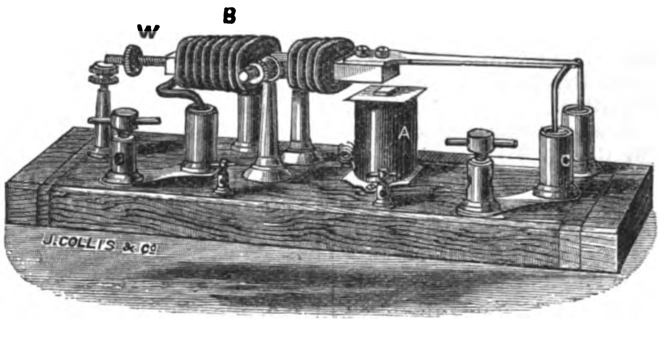
or output

$\propto$ (μ × peripheral velocity)$^{\frac{2}{5}}$ (Linear dimensions)$^{\frac{5}{2}}$.

(To be continued.)

KENT'S AUTOMATIC ACCUMULATOR SWITCH.

Various forms of automatic switches, designed to prevent the reversal of series or compound-wound dynamos when used



for charging secondary batteries, are already in use. The switch we illustrate herewith is one of the most simple that has come under our notice, and in delicacy and certainty of action leaves nothing to be desired. In the figure B is a coil of high resistance, provided with a soft iron core, and connected as a shunt upon the terminals of the dynamo. The polarity of this magnet is therefore independent of the direction of the current in the main circuit. A soft iron armature pivoted at or near its centre has wound upon it the thick wire coil A, which is placed in the main circuit, the connections being made through mercury cups. This armature carries a stout copper wire which dips into two mercury cups C, and makes or breaks the main circuit at this point. The connections of the large wire coil are such that the armature is held down as long as the current in the main is in the right direction; but if the battery overpowers the dynamo the polarity of the armature is severed, and the main circuit is instantly broken. The sliding weight w regulates the delicacy of the action, and the range of motion is limited by the stop on the left hand, which is adjustable in the vertical direction.

AN ARC LAMP FOR THE DUBOSCQ LANTERN.—In the April number of the *Philosophical Magazine* will be found an interesting paper by Prof. Silvanus P. Thompson, "On an Arc Lamp Suitable to be used with the Duboscq Lantern."

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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SPECIAL NOTICE.

With this week's issue of "The Electrician" each subscriber should receive (gratis) a Steel Plate portrait of Mr. W. H. Preece, F.R.S., Electrician to the General Post Office.

Further copies of the portrait can be obtained, price 6d. each, on application to "The Publisher," 1, Salisbury-court, Fleet-street, E.C.

CONTENTS.

Notes ... 473
William Henry Preece. (With Portrait.) ... 477
The Practice of Dynamo Design. By Guy C. Fricker. (Continued.) Illustrated ... 477
Kent's Automatic Accumulator Switch. Illustrated. ... 479
The Central Institution and Finsbury College ... 480
Correspondence ... 481
Submarine Cables ... 482
Applications of Electricity to Mining Operations. By F. J. Rowan, C.E. (Continued.) 483
On Varnishing Incandescent Lamps. By N. K. Cherrill. 484
The Evolution of an Ironclad Dynamo. (Concluded.) Illustrated ... 484
The Resistance of Faults in Submarine Cables. By A. E. Kennelly, M.S.T.E. (Continued.) Illustrated. ... 486
Influence of Stress and Strain on the Physical Properties of Matter. By H. Tomlinson, B.A. ... 487
Physical Society ... 489
Football ... 489
Oriental Telephone Company... 489
Telephone Company of Ireland 490
City Notes, &c. ... 490
Companies' Share List ... 490

THE CENTRAL INSTITUTION AND FINSBURY COLLEGE.

Some recent appeals for further pecuniary aid to the CENTRAL INSTITUTION have apparently led to inquiries as to the precise object of this establishment, as distinct from that of the Technical Training Institution at Finsbury. The so-called CENTRAL INSTITUTION—which, however, is situated at the West End of London—has cost a big sum of money already, and will cost a vast deal more before its fittings are completed; and for its proper maintenance a large additional annual revenue will be needed. Not unnaturally, the generous patrons who have helped forward the scheme of national technical instruction, and others besides the City and Guilds of London, have desired to learn whether the additional demands upon them for the endowment of the more costly of these establishments are warranted by the functions it will discharge in relation to the general scheme. We say not unnaturally, because, while the work of the Technical College at Finsbury, and that of the Art School at Kennington are conspicuous and easily computed, that of the CENTRAL INSTITUTE is not quite so obvious—at all events not to the non-scientific outsider. Accordingly an opportunity has been afforded some of its leading spirits to set this matter in its true light. At a Drawing Room meeting presided over by Prof. HUXLEY, and attended by a numerous gathering of sympathisers, about a month ago, Prof. AYRTON, the principal of the CENTRAL INSTITUTE, delivered an address explaining its objects, and the relative importance of the several colleges affiliated with it.

No better selection could have been made for the performance of this task. Prof. AYRTON'S address was, we need hardly say, full of sound knowledge of his subject and enthusiastic advocacy of its claims to public support. But it was also marked by a good deal of plain practical sense, which we hope and believe will have the desired effect upon those with whom the future of the Institute, financially speaking, wholly depends. We might find fault with the, as it seems to us, gratuitous disparagement of the educational systems which prevail at the great seats of learning; for whatever their defects may be, it is not to be supposed that Oxford and Cambridge will be converted to the exclusive study of physical science. They do not set out with that object, nor is it desirable they should; the CENTRAL INSTITUTION does start with that object, and Prof. AYRTON may be satisfied with having shown that it ought to succeed. For the purpose of training or completing the education of science teachers throughout the country, of whom we learn that between 200 and 300 will begin their studies after Easter, such an institute is absolutely indispensable. For the higher training of pupils from the minor establishments who desire to complete their education, and for the reception of exceptionally gifted students who have gained science scholarships, the CENTRAL INSTITUTE is the proper place.

But Prof. AYRTON went further than this. Not only, he observed, by means of technical education is the practical man trained to use his brains when he uses his hands, but what is equally important for the country's welfare, the scholar by receiving technical education learns to use his hands when using his brain, and thus puts the scholar—or as we should rather say the practical statesman—*en rapport* with his country's needs. This is a sound practical argument—the best, indeed, that can be urged—for, at all events, adding some physical science to the course of education which has been hitherto deemed sufficient for our public men. Anyone who takes umbrage at this little raid on the enemy's camp will immediately find consolation in watching the Professor make a similar dash at his own. "I have recently," he says, "been impressed with the fact that technical education has another important duty to fulfil, namely, that of bringing practice to science; in other words, giving scientific education the practical and technical experience of which it stands so much in need in order to make it of any enduring service to the student." This reflection has, no doubt, been forced upon Professor AYRTON by the circumstance that a number of students, who have already passed through a scientific course and taken their University degrees, are attending the CENTRAL INSTITUTION to receive a practical education. The connection between this higher education for University men, and for the exceptionally gifted from the ranks below, may not at first sight be apparent. But in reality the movement for technical instruction must be sustained from above; and the very fact that doubts have been raised on the subject proves that the value of such instruction, and the instruments necessary for carrying it on, are not as fully appreciated as they ought to be.

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W. H. Preece

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The cost of fitting and maintaining this CENTRAL INSTITUTE so far exceeds that of ordinary colleges and schools that Prof. AYRTON did well to explain this matter in detail, showing the necessity for having complete sets of apparatus and working machinery for each separate lecture room devoted to special subjects. The cutlay is no doubt very great; but, as was shown in the course of the meeting, not nearly so great as in many places on the Continent has been cheerfully borne. If once, however, the utility of the plans now for the first time inaugurated in this country is proved to the satisfaction of its patrons, we have no doubt that the liberality they have displayed so far will not stop short of its complete realisation. To work out this scheme in its entirety the CENTRAL INSTITUTE is a necessity, and even when we have spent upon it all that is asked we shall have done much less for scientific and technical education than some of the smaller towns of Germany, Austria, and Switzerland have been doing for many years past.

Of the FINSBURY COLLEGE the accounts are entirely satisfactory, and seem to be questioned by nobody. Prof. PERRY and Prof. S. THOMPSON explained the character of the instruction given there, and its relation to the higher functions of the CENTRAL INSTITUTION. More than one thousand pupils attend the evening classes in Finsbury; and, although it is more particularly intended for pupils who can only give their time after working hours, there are 157 day students as well. But for the most part they are young, their average age being 17, and they are nearly all from the workshop. To quote Prof. THOMPSON, "We have struck straight for the industries." The students are not taught to pass South Kensington examinations, but to become better workmen. From amongst these it may be presumed there will arise now and then a great man whom the CENTRAL INSTITUTE will befriend. It is, in the words of Prof. HUXLEY, "a capacity-catching apparatus;" and if in the course of the next ten years they succeeded in catching another FARADAY or WHITWORTH or ARMSTRONG, he would, from a commercial point of view, be worth all that we propose to spend on the operation. This, however, is a speculation; what is certain is that the general educational capabilities of the nation in the domain of technical industry will be greatly widened, and the standard of excellence proportionately raised. There are, it is true, some abuses to which endowed establishments of this kind are peculiarly liable; but they do not militate against the initial scheme, and may be discussed at a later period.

CORRESPONDENCE.

THEORY OF SECONDARY CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read Prof. Thompson's and Mr. FitzGerald's remarks on the thermo-chemistry of cells, and disagree entirely with both. Before criticising I will state what I may call my own theory, as I wrote it in the spring of 1883. ("Practical Electric Units" (Spon), chapter on chemical work.) In the first place, it is evident that chemical action does not account for the E.M.F. of a cell. If it did water would always take the same E.M.F. to decompose it, but it does not; with a peroxide of lead anode and a zinc cathode it takes nearly twice as high an E.M.F. as it does with two platinum electrodes. The existence of a cell with a single liquid giving two volts would also be anomalous if the electrolyte is dilute acid which can be decomposed by less. It is therefore evident that there are large contact potential differences between the electrodes and liquid over and above those due to chemical affinities. I called these Peltier effects, though the term is somewhat misapplied. These contact effects are being investigated, if I am not mistaken, by Bouty. They are also mentioned by Dr. Wright. The evident chemical action in a cell on discharge is formation of $PbSO_4$ on each plate. It is orthodox to say that the Pb is oxidised by nascent oxygen to PbO, and that the PbO is acted on by H_2SO_4 to produce $PbSO_4$ and H_2O. The second is generally known as a secondary or non-adjuvant action. Against these views I urge that there is no reason whatever to suppose that there is such a thing as nascent oxygen, and that there is no reason to suppose that two actions take place at all. There is more reason to suppose lead sulphate formed direct on each plate. To get the chemical work done in the cell we take the whole as it was before and as it is after discharge, and note the affinities where radicles are torn asunder, and those where they are brought together and add them algebraically. We may open a sort of debit and credit account. Starting at the spongy lead plate we have $Pb + SO_4 = Pb\,SO_4$, or, according to the more usual notation, Pb, SO_4. This is credited. Sulphuric acid has an affinity for water, or a large heat of solution. Debited. H_2 is parted from SO_4. Debited. This finishes one plate except as to the H_2. Before going further it must be remembered that the SO_4 goes from the liquid to the solid state. The latent heat difference is credited. On the other plate the peroxide may be taken to give up both atoms of O. Credited. The O becomes liquid. Latent heat debited. Part of the O combines with the H_2 of the other plate to form H_2O. Credited. Pb from which the O_2 has been torn combines with SO_4. Heat of Pb, SO_4 credited. The SO_4 has become solid. Heat credited. The H_2 of the acid forms H_2O with the other atom of oxygen from PbO_2. Heat credited. This O becomes liquid from solid. Heat debited. The details of all these actions are of course hypothetical; but it does not matter thermo-chemically in what order the combinations take place. The point is that the whole of the chemical and physical action is utilised. All these actions do not account for two volts. In 1883 I had no data for Pb, O_2, so did not work the example out.

If the actions are as described, we have still insufficient data. We want to know H_2, SO_4, both H_2 and SO_4 being liquid; heat of solidification of SO_4; Pb, SO_4 both solid; Pb, O_2 both solid. Some or all these may be got by a complicated process of inference.

Thermo-chemical data are given in the form of least use to electricians, as an electrician wants heats of combinations of radicles which cannot exist separately. Much trouble is caused by writers being indefinite, and not stating the physical states. Nor is this all; the greatest trouble is that one authority has hidden his work by writing it entirely in German, while the other has buried his in French, and in addition works with the old notation and a big calorie.

The E.M.F. due to formation of sulphate on both plates can be calculated by simply considering the final results, as the principle of the conservation of energy shows that the final results are alone to be considered. Without admitting the formation of PbO we can assume it as a hypothetical action, as we know the heat of Pb,O and of PbO, H_2SO_4 Aq., and these two include the whole action on the spongy plate. On the other plate we want to know PbO, O, and this has been quoted by Prof. Thompson. The radicles are bivalent, so the heats must be divided by 2.

$\frac{1}{2}$ Pb,O $= \frac{50300}{2} = 25{,}150$. This figure, taken from Thomsen, appears to be the heat of burning Pb in gaseous O, and would then be too high. The labour of reading Thomsen deters me from fogging the matter out. $PbO + H_2SO_4Aq. = 21{,}400$ according to Berthelot. Credit 10,700.

On the other plate PbO_2 reduced to $PbO = -12{,}140$. This is quoted from Prof. Thompson with fear and trembling. Debit 6,070. $PbO + H_2SO_4Aq. = 21{,}400$; credit 10,700. Adding all these up we get 40,480 as the total heat. This is probably too high, because of the 50,300. To get this to volts Lord Rayleigh finds a coulomb deposits ·00111794 grm. silver ∴ 1 gram of hydrogen takes 9,660·7 coulombs. Dividing by ·42 we get 23,000. The calories divided by $23{,}000 = 1·76$. The chemical actions, therefore, give 1·76 volt, and the cell cools on discharge. I have never noticed a cell cool, but have

observed that cocked hat batteries, which have very little resistance in proportion to their bulk and E.M.F., got very hot if water is decomposed in them. They were made of a pile of thin lead basins standing one inside the other.

Turning to Prof. Thompson, as reported in *The Electrician* and *Electrical Review*, he first assumes that the chemical action can be determined from the E.M.F., which is unwarrantable. He then says zinc dissolved in $H_2 SO_4$ gives 85,400 cals. If this figure is right it is not to the point, as hydrogen is evolved. It is suspiciously like the heat of Zn, O. Where does Prof. Thompson get 37,520 as heat of formation of $Cu SO_4$, and how is it formed? He goes on to say 46,000 cals = 1 volt. This is only for bivalent radicles. Prof. Thompson either does not include my theory or I do not recognise it. Taking the *Electrical Review* report, the figure 1·93 is got, which nearly corresponds with mine. This is the fourth, according to Prof. Thompson. The data are slightly different, the water is wrong but cancels out, and all being taken for bivalent actions the figure comes right when divided by 46,000. Prof. Thompson's first reaction is to me unintelligible. He begins $H_2O = 68,000$. This is approximately the heat of exploding what the Germans call bang-gas (mixture of sour-stuff and waterstuff), the result being liquid. The Professor then goes on to take half molecules, and divides by 46,000. It all reads like some frightful nightmare. Why not reduce everything to shillings and pence? He goes on to say, in *The Electrician*, that the lead sulphate is not adjuvant, and cancels out. If it is a secondary action, of course its formation would merely heat the cell, but by non-adjuvant Prof. Thompson means that it cancels out. It could only cancel out if formed at one plate and decomposed at the other. Thus in a Daniell cell you subtract one from the other, as the copper sulphate is decomposed while the zinc sulphate is formed. In a lead cell it is formed at both ends. If it were secondary, I will not say non-adjuvant, because it may lead to confusion, we would only consider formation of PbO.

½ PbO	= 25,150
½ PbO_2 reduced to PbO............	− 6,070
	19,080

So that Prof. Thompson would only get ·83 volt. Finally Prof. Planté's experiment does not show two stages. If a copper anode has a high current density, all the acid next it is used up, and the bulk of the copper has to combine with oxygen as it is no longer in an acid electrolyte. No doubt it then needs a higher E.M.F.

Turning to Mr. FitzGerald's article, he gives Andrews' and Dulong's figures for Zn, O as 42,282 and 42,185. Surely there is some error here; perhaps due to the old notation.

Mr. FitzGerald's main proposition is startling. He holds it as indubitable that the maximum E.M.F. is due to combination of the positive metal with the acid radicle of the electrolyte, and cannot be increased by the other plate, though it can be decreased. How does he get 52,900 as the heat of Zn, SO_4? and why should the heat absorbed in tearing the H_2 from the SO_4 be left out, and the heat of combination of water, &c., &c.? The heat of Zn, SO_4, or Zn/SO_4, as Mr. FitzGerald and Prof. Thompson write it, must not be confused with the heat of dissolving zinc in dilute acid; it is a different thing. Why should one little bit of the action at one plate be taken alone? Mr. FitzGerald seems to regard the evolution of hydrogen as normal at the peroxide plate, and looks at the peroxide as merely a way of getting rid of it. Any chemical action not devoted to E.M.F. must of course appear as heat. How does Mr. FitzGerald arrive at 46,245 as heat of Pb, SO_4? If this were the only action to be considered, a lead cell would only give 1 volt as Pb, SO_4 is bivalent. I make Pb, SO_4 156,110, but have not checked my figures. This is taking Thomsen's data. This gives 3·4 volts. It does not seem necessary to suppose that Pb O_2 owes its oxidising properties to formation of sesquioxide. In nearly all cases where it acts as an oxidising agent a protosalt of lead is formed, not a sesquisalt, and if a sesquisalt were formed we would expect a sesquisulphate, not a sesquioxide. Mr. FitzGerald allows that the affinity for SO_4 makes $PbSO_4$ at one end, but at the other he neglects this altogether, and assumes a sesquioxide, which cannot exist in the presence of sulphuric acid.

I need hardly say anything further against the nascent gas, and the oxide theories here, for in the discussion on Prof. Lodge's, and in my own paper at the Society of Telegraph-Engineers I have gone into the question.

To me it is impossible to follow Prof. Lodge, Mr. FitzGerald, or Prof. Thompson, and I have only one comfort—that is, that they can never understand one another.—Yours, &c.,

JAS. SWINBURNE.

MERCURY CONTACTS AND THE USE OF CELLULOID IN SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read Mr. FitzGerald's letter in your last issue (page 461) with some astonishment, as both he and Mr. Jones must be fully aware that my firm exhibited at the Mining and Engineering Exhibition, held at the Agricultural Hall in the year 1883, samples of the Woodward spongy lead plates divided by celluloid combs. We also exhibited a complete set of batteries, which were used to light our stand, with plates clamped to American celluloid frames, through which the leads passed, also being supported by Blake's ebonitea, a material which we preferred, being more suited to this purpose than Dr. Fleming's British insulite, a material then in vogue and used for similar purposes.

Four of these batteries are still in existence, and are used by us daily as a standard test for our low-resistance 8-volt battery lamps.

I may further say that the use of mercury connections is not a very new idea, and it has certain disadvantages which I have frequently noticed in several installations in Belgium and Holland. I am obtaining some reliable data upon this point, which I will forward for publication, with your permission, later.—Yours, &c.,

ARTHUR SHIPPEY.

13 and 14, King-street, London, E.C.,
April 5, 1887.

TAUSSIG'S AUTOMATIC FIRE AND BURGLAR ALARM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Higgins's letter in your last issue I beg to state that Dr. Taussig's patent is for a *combined automatic and manual alarm, with additional telephonic communication*, and not for an *automatic alarm only* as Mr. Higgins's patent.

There is no part in either apparatus which is patentable; the cam wheel, the automatic recorder, and all other appliances being used in all telegraphic systems. The combination, however, of automatic and hand-worked call, together with facility of introducing the telephone on the same line, is novel, and due to Dr. Taussig.—Yours, &c.,

JULIUS MAIER.

4, Westminster-chambers, Victoria-street,
April 4, 1887.

SUBMARINE CABLES.

In our last issue we formulated a text which, we contend, has been overlooked by some critics of submarine telegraphy. Is the work to be carried out in future upon business principles, or is it to become the *protégé* of Governments—a semi-international, State-aided, State-supervised, beaurocratic concern which it is nobody's interest to keep effective?

We maintain that the original pioneers of cable work were business men, acting as business men, and dealing with others as business men. Commercial centres were connected by telegraph because telegraphing was possible in a remunerative sense only from such centres. Gradually but slowly the eyes of politicians were opened to the value of cable connections between various parts of the world. England as a "nation of shopkeepers" very soon realised the value of these telegraphic links, and did not hesitate to embark capital in carrying out cable schemes whenever they showed a fair

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prospect of success. It was but natural that the companies should endeavour to protect themselves by obtaining a monopoly of telegraphic rights wherever and whenever possible. In order to secure the communication various Governments granted such rights. In some cases, more frequently in recent years, subsidies have been granted to various companies as an inducement to embark in the risk of a new link to the system. From a business point of view the companies would not think of asking for a subsidy if the prospects of a sufficiently large commercial and social traffic was assured—this traffic, of course, being of such dimensions as to ensure a fair return for the capital sunk in the scheme. Subsidies, as we say, have been asked and have been granted when the prospective traffic was deemed insufficient to warrant the necessary outlay for connection, or when increased facilities were demanded for which the ordinary income could not pay.

The companies have had sufficient troubles to encounter and overcome to deter many bold men of business from investing their capital in what they deemed so risky a concern. We need not enter fully into the perils which beset the latter from its birth to its grave. It is but a frail thing, and has to be tenderly handled, and is subject to attack and disaster from all sides. When placed upon its ocean bed it is by no means safe from attack, and the officials know not from moment to moment what the next may bring forth. The work of a teredo, the swell of the ocean, the action of a river, submarine convulsions, the drag of an anchor, or half a score of causes may render a large capital valueless. These are natural enemies, and these have been sturdily combated by the officials of the cable companies till they may fairly claim to have made a cable nearly as secure as a building upon the solid land.

They understood that the fight would have to be fought against these natural foes; but they did not foresee that the fight with their own clients would be so arduous. In the early days of submarine telegraphy codification was unknown; but now one word is made to do the duty of a score, to the detriment of the receipts of the cable companies. Still, this codification has not been an unmixed evil. The receipts have been decreased in one way, but they have been increased in another form—the greater facilities given to business.

The worst enemies of the cable companies are the officious official and the meddlesome politician. These men think they know better how a particular business should be conducted than those engaged in the business themselves, and the question of the moment is, how far a paternal Government shall interfere with a private business ?

Since the above was written Mr. Henniker Heaton has, as one of the critics of the cable companies, stated his reason for the support of a scheme which seems to us unbusinesslike. We shall therefore consider Mr. Heaton's conclusions, but as our space is considerably restricted in the present number, our remarks must be left to another issue. This is more necessary as Mr. Heaton contends that the companies are altogether wrong in the tariffs they charge; in other words, that Mr. Heaton is a better judge than the managers of the companies how this particular business should be conducted. We shall have no difficulty in showing how small are Mr. Heaton's claims to be accepted as an authority on these points.

APPLICATIONS OF ELECTRICITY TO MINING OPERATIONS.

BY F. J. ROWAN, C.E.

(Continued from page 465.)

I. Electrical Transmission.

The useful effect of this system is the product of the following partial effects :—

1.—The useful effect of the generator or dynamo machine.
2.—The useful effect of the conductor (wire or cable).
3.—The useful effect of the receiving machine or motor.

It is also necessary to distinguish in the total useful effect the *electrical* effect, which is given by the relation of the E.M.F. of the generator to that of motor, and the *mechanical* effect, or the relation of the effective work recovered to the total work supplied to the system

The total resistance of the circuit must be known to obtain the electrical yield, and the author assumes 50 per cent. of the total resistance to be due to the generator and motor. This is much greater than has been found to exist in the experiments of Marcel Deprez and others. The resistance of the conductor is fixed by its section and material, this section being calculated in square centimetres for a given current by the formula $S = \frac{I}{60}$, when copper is the metal supposed, and I = the intensity of the current in amperes. Suppose that we transmit successively 5, 10, 50 and 100 effective H.-P., the yield of the system being 50 per cent., and the maximum tension used 1,500 volts, with currents of 5, 10, 50, and 100 amperes, then we should obtain the following results :—

For intensities of	5	10	50	100	Amperes.
Section of copper conductor	0·083	0 166	0·833	1·666	Cent².
Resistance in ohms per kilometre of conductor..	2 03	1·01	0 20	0·10	Ohms.
Loss of energy in kilo grammetres per second, according to $\frac{I^2 R}{9 \cdot 81}$	5·17	10·34	51·73	103·46	$= A_0$.

If K in kilometres be the length of transmission so that the total length with return wire is 2 K, this gives a loss of energy $= 2 K A_0$. According to the preceding suppositions, the loss due to the machines being the same, then the *electrical* yield of the system is—

$$E_u^1 = \frac{\frac{E I}{9 \cdot 81} - 4 K A_0}{\frac{E I}{9 \cdot 81}} = 1 - \frac{4 K A_0}{\frac{E I}{9 \cdot 81}}$$

or

$$E_u^1 = 1 - 0 \cdot 0027 K.$$

To arrive at the *mechanical* yield we must take into account the loss of energy due to transformation. Supposing that 87 per cent. of the power furnished by the prime motor is transformed into electricity, and again 80·6 per cent. of this energy is transformed into mechanical power by the motor, then we must multiply the electric yield by $0 \cdot 87 \times 0 \cdot 806 = 0 \cdot 70$ in order to obtain the definite mechanical yield—

$$E_u = E_u^1 \times 0 \cdot 070 = (1 - 0 \cdot 0027 K)\ 0 \cdot 70,$$

and from these data we get the following results :—
For distances of—

Metres	100	500	1,000	5,000	10,000	20,000
E_u =	0 69	0 68	0·65	0·60	0·51	0·32

These figures, are, however, considerably under the results which have been obtained in practice, and may be taken as minimum results. This author estimates the cost of electrical installations as follows :—

For the transmission of 5 h.-p. to 100 metres, total fr.		9342·50,	or about	£374.
,,	10	,,	13,255,	,, £530,
,,	50	,,	50,750,	,, £2,030.
,,	100	,,	81,950,	,, £3,278.

II. Hydraulic Transmission.

The elements whose useful effects have to be considered in this system are—

1st. A force pump when a natural head of water is not available.
2nd. Pipes and accumulator.
3rd. Hydraulic motor, either turbine or water pressure engine.

The theoretical work necessary to raise a quantity of water, Q, to a height, H, is represented by $A = Q H \delta$, when δ = weight of unit volume. If A_1 be the effective work necessary, the useful effect is—

$$E_u = \frac{A}{A_1} = \frac{Q H \delta}{A_1}$$

or $E_u = \frac{Q \delta (H + h)}{A_1} \cdot \frac{H}{H + h}$ when h = loss of water by friction expressed in height of water. The first factor represents the useful effect of the pump, and the second that of the pipes. For well constructed pumps, a useful effect of 0·90 to 0·93 may

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be taken, for pumps of average construction 0·80 to 0·90, while rotary pumps have an estimated useful effect of 0·70.

Pipes.—The loss of force by water in traversing a long pipe $= h = \beta \frac{l}{d} \cdot \frac{v^2}{2g}$ where l = length of pipe, d = diameter of pipe, v = velocity of water. β = a co-efficient determined by experience.

The best diameter of pipe can be found by $d = 0{\cdot}816 \sqrt[7]{Q^3}$.

For average heads of water and diameter of pipes, the useful effect of pipes is for distances of—

Metres	100	500	1,000	5,000	10,000	20,000
E^1_u =	0 997	0·985	0·970	0 85	0 70	0·40

The hydraulic motors which are usually employed are either turbines or water pressure engines, giving a yield of from 60 to 75 per cent.

The product of these three partial useful effects gives the useful effect of the system.

III. Compressed Air Transmission.

We have here—1st, Compressors;
2nd, Conducting pipes; and,
3rd, Air engine, analagous to a steam engine.

The useful effect of this system is extremely small where compression takes place according to adiabatic curves, so that, for a compression of 10 atmospheres, not more than 51 per cent. would be realised, the remaining 49 per cent. being absorbed in heat which is uselessly dissipated during the travel of the air. Isothermic compression, as carried out by Colladon at St. Gothard, should be used, as by means of injecting cold water into his compressor cylinders, Colladon succeeded in compressing to 8 atmospheres without raising the temperature of the compressed air more than 25° C.

It is also necessary to use hot water in the air engine, so that the temperature there does not fall below 0° C., when ice forms in the cylinder. Under these circumstances, a useful effect of 80 per cent. for compressor may be obtained, and, in the air engine, a mean of 75 per cent. is found to be attainable for good permanent installations.

The loss in the pipes is small, being found to be 1·3 per cent. per kilometre. Multiplying the three percentages together, we obtain, for distances of—

Metres	100	500	1,000	5,000	10,000	20,000
E_u =	0·55	0 55	0·55	0 55	0·50	0·50

When drills are substituted for the air engine, the useful effect is very much less.

(To be concluded.)

ON VARNISHING INCANDESCENT LAMPS.

BY NELSON K. CHERRILL.

In a recent number of *The Electrician* it is mentioned that Messrs. Siemens and Halske have recently adopted the system of dipping lamps in a thin semi-transparent varnish to obtain the effect of ground glass. As the writer has had much experience in this class of work, a few notes of the best mode of procedure may be of interest. The application of various modifications to the normal appearance of a lamp by means of varnish either coloured or plain is by no means a novel expedient, and a similar plan has, I believe, been commonly employed in many places for decorative work.

The most important point in the application of varnish to a lamp is to get it to dry just in the right condition. Most kinds of varnish that will dry "bright" under ordinary circumstances will become "matt" if subjected to a chill, or to the action of damp during the drying, and at the same time many varnishes intended to dry with a "matt" surface, that would represent ground glass, dry "bright" if the conditions of drying are not quite suitable.

The class of varnish best adapted to this kind of work is what is known as photographer's negative varnish. This class of varnish dries almost as hard as the glass itself, and when well applied is very durable. When coloured lamps are needed the varnish should be of a quality to dry "bright," but when the effect of ground glass only is required the simplest way is to use what is known as "retouching" varnish which gives a "matt" surface at once. In default of this, the ordinary negative varnish can be easily modified to give the desired surface by the addition of a little weaker alcohol, which almost always has the desired effect; but if there is any difficulty a little common resin, which chills very easily in drying, may be added to the varnish.

As to the mode of applying the varnish to the lamps, the best plan is to hang them on a frame by their contacts, so that a current can be passed through them during the operation. The lamps should be well washed in warm water in which there has been dissolved a liberal dose of soda; a thorough rinse with fresh cold water should be given, and the bulbs should then be carefully wiped quite dry with clean linen rags. If the work is to be very nicely done, the operator who hangs up the lamps on the screen should have on linen gloves, as finger marks on the glass are apt to show when the whole process is finished. The varnish is poured into an upright glass vessel large enough to contain the lamp; a common drinking glass is as good as anything if large enough to admit the lamp. In pouring out the varnish care should be taken not to disturb any sediment which may be at the bottom, and if not quite clear it should be filtered, as it is of the greatest importance to avoid any small floating particles, which would cause spots or streaks on the finished surface.

All being ready, if the varnish is to dry bright, *i.e.*, for coloured lamps, &c., switch on the current to the lamp for a few moments, so as to render it slightly warm. Then turn it off, and taking the glass of varnish in the left hand, raise it under the lamp until the whole globe is immersed. If the lamp is in any kind of rigid fitting it will be very easy to immerse it, but if it is merely hung on a couple of wires, it will require the aid of a little instrument, consisting of a forked piece of wood, to push the globe down into the varnish. As soon as the varnish entirely covers the globe lower the glass with one steady movement, so that the draining off the superfluous varnish shall be commenced in one even wave all over the globe; any hesitation or pausing in the motion of the glass will be almost sure to cause a line on the finished lamp.

As soon as the tumbler of varnish is quite clear from the lamp turn on the current again, and leave it running, while several more lamps are being done. When about twelve lamps have been varnished the first will be ready to come off. But a little care must be taken till the lamp is quite cold, as some varnishes will finger mark readily at this stage. If the varnish is to dry "matt" the lamp should be plunged quite cold, and no current should be put into the lamp till the varnish has chilled all over, then a little warmth will aid the drying, and will also harden the varnish. Almost any colour can be given to the varnish by the simple use of Judson's dyes, which will readily mix with the varnish and impart their characteristic tints.

Blue is the most difficult colour to arrive at satisfactorily, as the dye does not seem to blend so well with the varnish as the other colours, and, besides, the colour is spoilt by the yellow tone of the light. To avoid this part of the difficulty the lamps which are to be used blue should be run as *hot* as possible, while those for red or yellow colours may be comparatively cool, the yellow especially so.

It goes without saying that all the testing of the lamps must be finished before the varnishing is commenced.

A pleasing effect is sometimes produced for purely decorative work by using a little dye with the "matt" varnish.

THE EVOLUTION OF AN IRONCLAD DYNAMO.

(Concluded from page 466.)

Taking all these points into account, the question presented itself like this: How to construct a magnetic circuit of the least resistance, with the least liability to scatter, and so constructed that the magnetising effect of the exciting helix is made to surround magnetic material of the largest cross-section in the machine. The experiments with unipolar machines referred to before seemed to furnish a number of points to answer this question. While experimenting with unipolar machines, an experiment was made with a machine shown in Figs. 17 and 18.

A core of wrought-iron, A, which acted as the armature core, was surrounded by a cylindrical cheek piece, B. The machine had six coils C D E F G and H. The first four coils had exactly the same quantity of insulated wire as the two last ones, but the value of the machine as a generator was nearly doubled when the two coils on the armature were used to excite it than when the four coils were used. In the one case the armature core was magnetised by the electric current directly, while in the other case it was magnetised by magnetic induction from the cylindrical cheek B. This experiment and various others seemed to prove that there is a loss of energy when the core of the armature is polarised by magnetic induction, and that the best results can only be obtained in unipolar machines, at any rate, when the armature core is magnetised by the exciting helix directly.

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Another set of experiments had demonstrated another point. When a conductor is rotated around the end of the magnet, a current is produced which may be taken off by means of brushes. Fig. 19 is an illustration of such a device. The magnet core A is surrounded on one end by a helix, B, by means of which it is magnetised. An armature, C, surrounds the projecting end of the core. If the armature C is rotated a current is produced. The magnetic current which in this case passes through the iron has to complete its circuit through space. In Fig. 20 the same magnet core, exciting helix, and armature are shown, but the whole is enclosed in a shell of iron, D. This shell D furnishes a metallic conductor for the magnetic current, and reduces the air space through which the magnetic current has to pass to a minimum. The core A is surrounded by the hollow annular shell D, and the air space is reduced to an annular ring in which the armature is rotated. The relative values of the two devices are almost as 1 to 2. In the first instance the great resistance in the magnetic circuit caused scattering of the lines of force into space, while in the second device none or but very little external magnetism appeared.

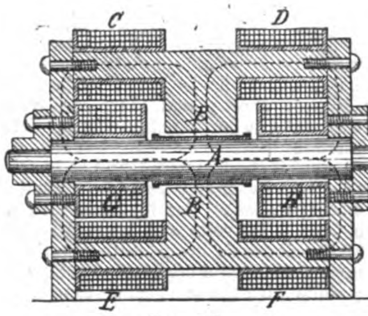


FIG. 17.

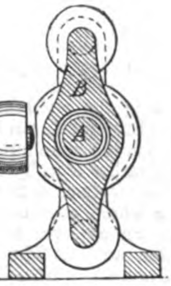
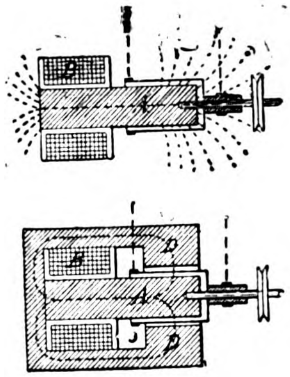


FIG. 18


FIGS. 19 AND 20.

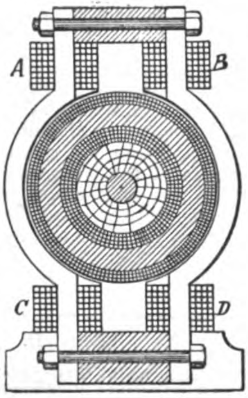


FIG. 21.

These experiments seemed to demonstrate that the best results were produced in unipolar machines when the exciting coil surrounded and magnetised the armature core, and second, when the armature core and helix were completely enclosed in a shell of iron. It seemed but reasonable to suppose that the same favourable results should accrue if these principles were followed in the construction of bipolar or other multipolar machines. The problem presented itself in this form: How to construct the magnetic circuit of a bipolar dynamo machine, which would have the greatest cross-section throughout, and be so short that it could not be cut again? and how to construct an exciting helix which would magnetise the armature directly, and a shell which, while it surrounded both armature and coils, would complete the magnetic circuit?

A number of small machines were made, in which the exciting helix surrounded the armature core; both housed in iron shells, and their efficiency tested and compared with machines of the common type of the same size. But in order to test the relative values of the two methods it was finally decided to construct a machine which could be readily changed from the common method to the new. The machine was tested under precisely similar conditions, first with four common coils which excited the electro-magnets and afterwards with four coils which surrounded the armature. The machine is shown in Figs. 21, 22, 23, and 24. A ring armature 8in. diameter, 6in. long, wound in 64 sections, fitted into a frame as shown in section, Fig. 21. The electro-magnets were of the Siemens type, made of soft iron bars, and each set of bars, five on each side, were wound with 60 pounds of No. 7 B and S gauge, double insulated wire in four spools as at A B C D. The machine was now thoroughly tested as a series machine. After this test four other helices were substituted for the first, as shown in Figs. 22 and 23 at B B.

These also contained 60 pounds of No. 7 B and S gauge, double insulated wire; but instead of surrounding the legs of the electro-magnets, they surrounded the armature longitudinally, magnetising it directly, while the electro-magnets acted like the shell in Fig. 20, viz., as conductors of the magnetic current from side to side of the armature, furnishing a double circuit for the magnetic current. The machine was now tested again and the results proved that the machine had been greatly improved.

Very little magnetism could be detected on the outside, although but a small part of the exciting helices was enclosed in the outer bars. The magnetic conditions in the two forms seemed to be about as shown in Figs. 23 and 24, in which the magnetic circuit of both machines is shown in horizontal cross-section. The magnetic

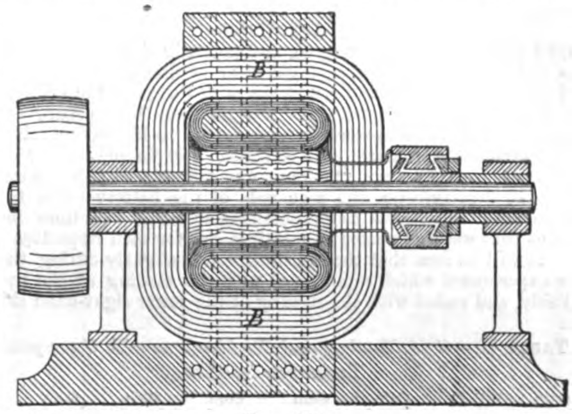


FIG. 22.

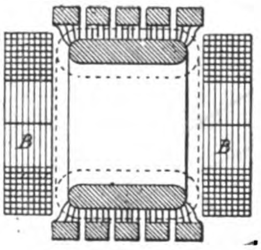


FIG. 23.

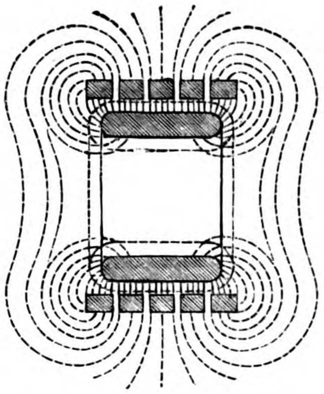


FIG. 24.

current in the one case, when four coils magnetised the five bars on each side as in the common method, made very strong poles of the bars opposite the armature, which would attract any bar of iron with considerable force. But in order to find external magnetism when the new coils were used it was necessary to use a compass needle. The electro-magnets would not hold a tenpenny nail. Yet when $\frac{7}{16}$ of the longitudinal helix was used the electromotive force of the machine was equal to that when the four common coils were used. Careful measurements showed that the machine was at least 30 per cent. better with the new coils than with the old, and a continuous use of some months to feed a number of 50-volt incandescent lights has demonstrated the fact that it is as reliable as any machine of its size using common electromagnets.

Many other experiments, not described in this paper, were made to verify the conclusions reached by the writer, and in all cases the results were the same. As in the unipolar and bipolar machines, so in multipolar machines, the value of the wire in the exciting helix was nearly doubled when used to magnetise the armature directly, instead of by induction by means of electro-magnets as heretofore employed, and it would seem as if this construction furnished the greatest electric effect with a given quantity of exciting wire, and the smallest loss of current.

The conclsions reached may be stated as follows:—The ideal dynamo machine should have an armature core of a length about equal to its diameter, so that the armature coils would enclose the greatest quantity of magnetic metal, with the least length of wire. The exciting helices should surround the armature longitudinally, and armature and exciting helix should be surrounded by a mag-

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netic shell laminated probably like the armature core, and of a cross-section equal to the longitudinal cross-section of the armature core.

This construction would furnish a magnetic circuit so short that it could not be cut a second time, and the resistance in the magnetic circuit itself would be so small that no part of the magnetic current would complete its circuit in spaces.

RESISTANCE OF FAULTS IN SUBMARINE CABLES.*

BY A. E. KENNELLY, M.S.T.E.

(Continued from page 470.)

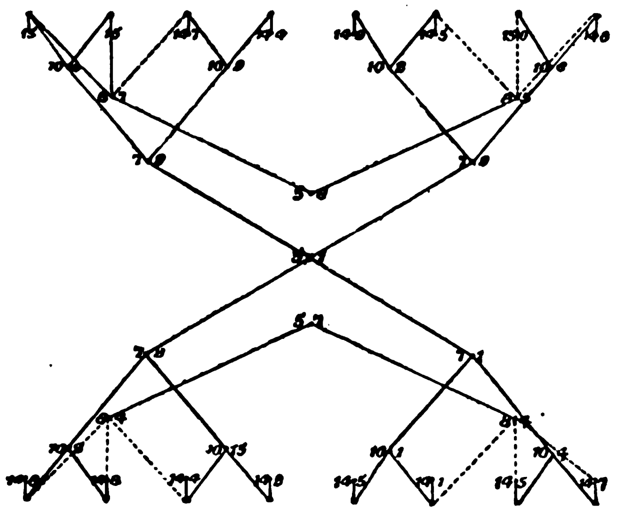
As further experimental proof of the law of inverse square roots, after eliminating the effects of polarisation, the following experiment may be added :—

Experiment.

Eight golden coins (sovereigns), mechanically cleansed, were immersed in sea water. By means of a single turn of fine insulated copper wire, bared at the end, and wound round the milled edge of the coin, electrical communication was obtained. The resistances of the exposures formed by the surface of these coins were then measured to immediate false zero, in their different combinations, as in series No. 1 of Table I. in our last issue. The current in the exposure circuit was maintained approximately constant at 10 milliamperes, the zinc pole of the battery being to bridge. The following table shows the resistances observed, the lines indicating the coins that were connected in multiple arc for each respective observation. It will be seen that the resistances fell slightly during the course of the experiment, which commenced with the reading at the upper left-hand side, and ended with the reading at the lower right-hand side of the table.

TABLE II.—*Coin Numbers and Combinations with Corresponding Resistances in Ohms.*

Coin No. 1. Coin No. 2. Coin No. 3. Coin No. 4. Coin No. 5. Coin No. 6. Coin No. 7. Coin No. 8.



Coin No. 1. Coin No. 2. Coin No. 3. Coin No. 4. Coin No. 5. Coin No. 6. Coin No. 7. Coin No. 8.

These observations may be classified as follows :—

						Ohms.
Mean resistance of exposure singly		from	16	readings	......	14·64
„ „	2 at a time	„	8	„	......	10·28
„ „	3 „	„	4	„	......	8·50
„ „	4 „	„	4	„	......	7·18
„ „	6 „	„	2	„	......	5·75
„ „	8 „	„	1	„	......	5·10

From 14·64, the mean resistance singly, and the law of inverse square roots we have :—

			Ohms.
Mean resistnace calculated of exposures	2	at a time	10·35
„ „ „	3	„	8·45
„ „ „	4	„	7·32
„ „ „	6	„	5·98
„ „ „	8	„	5·18

The discrepancies between the actually observed and the calculated results are thus all less than a quarter of an ohm, and if, the law being assumed, the mean readings are corrected to it instead of to the arithmetical mean, the discrepancies are still less.

The admission of the truth of this law for varying exposures and constant current makes, as we have already seen, the same admission necessary for the law with varying currents and a constant exposure, and hence the latter must hold good for all faults. But where the exposed surface is very small the products of electrolysis, not finding a clear path for free discharge, reduce the area of exposure in a variable manner, so that for such faults it is not to be expected that their resistances will obey the law. For suppose a constant difference of potentials to be maintained between the end of a cable that has a small fault and earth, the first current which flows through the exposure may be in accordance with the law. The accumulating and partially imprisoned gases or salts developed by electrolysis soon, however, reduce the actual area of liquid contact, and the resistance, we may suppose, will rise proportionally to the square root of this reduction of area inversely. This increased resistance will in its turn diminish the traversing current, thus tending to alter the electrolytic development, and so a continual readjustment and variation goes on in the observed resistance. When, however, the exposed surface is of such dimensions that the gases developed are readily disengaged, and do not accumulate, we may expect the observed resistances to fall within the law. This is, fortunately, the case in the majority of exposures that broken cables offer.

Turning now to the practical view of the subject, it may well be urged that it is impossible to arrive at the true resistance of the exposure with a broken cable by observing to immediate false zero, on account of the electrostatic discharge from the cable at the moment of interrupting the testing current ; and since the apparent resistance of a fault measured to a false zero after one or more seconds' interval appears to follow a doubtful and complicated law, the knowledge of the actual law of inverse square roots, though scientifically interesting in itself, would lead to very little practical success in fault localisation.

Although the force of this objection cannot be denied, still it would appear in practice that for feeble currents—that is to say, testing currents below 25 milliamperes—the observed resistances do not seriously diverge from the law, except, perhaps, where the length of cable between the observer and the break is very short ; and that, consequently, by observing the resistances with definite current-strengths the actual resistance of the break can be determined.

This is the more fortunate, since if the law were found to be followed by strong rather than by weak currents its efficacy would be limited to breaks comparatively close to the testing station. For instance, with a battery power whose electromotive force is 50 volts and internal resistance 100 ohms, an observer using a Wheatstone's bridge with a ratio of 100 ω ; 1,000 ω can force 25 milliamperes through a break offering 50 ω when it is 1,740 ω distant from him ; while with the same connections he could not force 200 milliamperes through the break further than 30 ω from him, even if it only offered 10 ω resistance at the time.

The following tables are copies of the results obtained with actual breaks, during the last six months, in the cables of the Eastern Telegraph Company, by whose permission they are placed before the Society. In all these observations the law is submitted to a crucial examination, because the readings are here given just as they were obtained, and before the resistances of the various faults were at all accurately known. It was only in the last case, illustrated at Table VI., that the law was so far relied upon from previous experience as to assist the judgment in assigning the position of the break. In all but this last case the correct distances and resistances of the breaks were ascertained from tests on board the repairing ship that recovered the broken ends. All the readings were taken by bridge to a false zero on a rather dead-beat galvanometer as soon after the cessation of the battery current and the discharge from the cable as possible—generally between one and two seconds' interval.

TABLE III.—*Broken Cable No. 1.*

I. Number of Milliamperes in Testing Current passing through the Break. Zinc to Line.	II. Corresponding Resistance of Cable and Break observed.	III. Distance of Break as subsequently determined.	IV. Consequent Resistance of Break as observed.	V. Calculated Resistance of Break from No. 4 on law of inverse square roots.
	Ohms.	Ohms.	Ohms.	Ohms.
1	860	598·6	261·4	262·8
2	800	...	201·4	185·8
3	750	...	151·4	151·7
4	730	...	131·4	...
5	712	...	113·4	117·6
6	705	...	106·4	107·3
7	700	...	101·4	99·3
8	695	...	96·4	92·9
9	690	...	91·4	88·6
10	685	...	86·4	83·1
11	680	..	81·4	79·2
12	675	...	76·4	75·9
13	672	...	73·4	72·9
14	669	...	70·4	68·6
15	666·5	...	67·9	67·9
16	665	...	66·4	65·7

The lowest resistance that could be obtained by Lumsden's method was 630 ω at 13·5 milliamperes through the break, corresponding to what might have been expected from the above series at about 70 milliamperes. The allowance for the break then made was 30 ω, so that the estimated distance of the break was 600 ω. The close agreement between the figures of the two last columns is very striking, especially as the law was not known when the observations in Column I. were made. In Column V. the results are calculated from reading No. 4, the geometrical mean. The length of conductor exposed was found, on picking up the broken end, to be about ¼ inch.

On the recovery of the broken end by the repairing ship the length of

* Paper read before the Society of Telegraph-Engineers and Electricians.

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TABLE IV.—*Broken Cable No. 2.*

I. Strength of Testing Current. Number of Milliamperes through Break, approximately. Zinc to Line.	II. Corresponding Resistance of Cable and Break observed.	III. Actual Distance of Break as subsequently discovered.	IV. Consequent Resistance of Break as observed.	V. Calculated Resistance of Break from first observation with 4 Milliamperes by law of inverse square roots.
	Ohms.	Ohms.	Ohms.	Ohms.
4	230	144	86	...
5	220	...	76	76·9
6	215	...	71	70·2
7	210	...	66	65 0
8	205	...	61	62 2
9	200	...	56	57·3
10	196	...	52	54·4
11	193	...	49	51 9
12	190	...	46	49·7
14	188	...	44	46·0
15	187	...	43	44·4
16	186	...	42	43 0
18	183	...	39	40 5
20	181	...	37	38·4
25	178	...	34	34·4
30	176	...	32	31·4
35	175	...	31	29 1
40	174	...	30	27 2
45	173	...	29	25·6
50	171	...	27	24·3
55	170	...	26	23 2
60	169	...	25	22 2
65	168	...	24	21·3
70	167·5	...	23·5	20·5
80	166·5	...	22·5	19·2
90	165 5	...	21·5	18·1
100	165	...	21	17·2
140	163 5	...	19·5	14 5

TABLE V.—*Broken Cable No. 3.*

I. Testing Current through Break. Milliamperes. Zinc to Line.	II. Resistance observed, Cable and Break.	III. Distance of Break subsequently known.	IV. Consequent Resistance of Break observed.	V. Calculated Resistance of Break from first observation.
	Ohms.	Ohms.	Ohms.	Ohms.
5	71	22	49	...
10	60	...	38	34·7
15	55	...	33	28·3
20	50	...	28	24·5
25	46	...	24	21·9
30	43	...	21	20·0
35	41	...	19	18·5
40	40	...	18	17·4
45	39	...	17	16·3
50	38 5	...	16·5	15·5
55	38	...	16	14·8
60	37·5	...	15·5	14·2
70	36·5	...	14·5	13·1
80	35·7	...	13·7	12·3
90	35·1	...	13·1	11·7
100	34·8	...	12·8	10·9
120	34	...	12	10·0
140	33·3	...	11·3	9·2
160	33	...	11	8·7
180	32·6	...	10 6	8·1
200	32·2	...	10·2	7 7

conductor exposed was found to be 0·9 cms. The Lumsden minimum was 157 ω with 150 milliamperes.

By comparing Columns IV. and V. in Table IV. it will be seen that for current strengths greater than 25 milliamperes the observed resistances of the break begin to depart from the law, owing, no doubt, to the necessary loss of time in false-zero reading.

For instance, before 25 milliamperes are reached—

The observed resistance of the break being 86 ω at 4 milliamperes,
ought by the law to fall to 43 ω at 16 ,,
and by Column IV. apparently did so at 15 ,,
Also, the resistance of the break being 76 ω at 5 ,,
ought by the law to fall to 38 ω at 20 ,,
and apparently did so at 19 ,,

But after passing the range of 25 milliamperes—

The resistance of the break being 39 ω at 18 ,,
ought by the law to fall to 19·5 ω at 72 ,,
but it apparently did not fall to 19·5 ω until 140 ,,

In the following case the result is not quite so accurate as in the two preceding. The cause of this may perhaps be accounted for later on. By the application of the law, however, to the resistances observed with currents below 25 milliamperes, the calculated distance of the break is only 2·5 ω from the true position. The Lumsden minimum was 32 ω at about 200 milliamperes.

Here, again, before 25 milliamperes—

The resistance of the break was observed to be 49 ω at 5 milliamperes,
and by the law should fall to half, 24·5 ω at 20 ,,
apparently doing so at 24 ,,

Beyond 25 milliamperes—

The resistance of the break was observed to be 21 ω at 30 ,,
and by the law should fall to 10·5 ω at 120 ,,
apparently doing so at 190 ,,

TABLE VI.—*Broken Cable No. 4.*

I. Testing Current Milliamperes. through Break. Zinc to Line.	II. Observed Resistance of Cable and Break.	III. Estimated Distance of Break.	IV. Consequent Resistance of Break observed.	V. Calculated Resistance of Break from observation with 4 milliamperes.
	Ohms.	Ohms.	Ohms.	Ohms.
1	1,888·2	1,778	110 2	90·2
2	1,833·2	...	55·2	63·8
3	1,828·2	...	50·2	52·1
4	1,823 1	...	45·1	...
5	1,818·1	...	40·1	40·3
6	1,813·1	...	35·1	36·9
7	1,811·1	...	33·1	34·1
8	1,809·1	...	31·1	31·9
9	1,807·1	...	29·1	30·0
10	1,805·1	...	27·1	28·5
11	1,804·1	...	26·1	27·2
12	1,803·1	...	25·1	26·0
13	1,802	...	24	25·0
14	1,801	...	23	24·1
15	1,801	...	23	23·3
16	1,800	...	22	22·6
17	1,799·5	...	21·5	21·9
18	1,799	...	21	21·3
19	1,799	...	21	20·7
20	1,798·5	...	20·5	20·2
21	1,798·5	...	20 5	19·7
22	1,798	...	20	19·2
23	1,797·5	...	19·5	18 8
24	1,797	...	19	18 5

The actual distance of this break was not determined, but the estimated distance, 1,778 ω, must have been very near the truth, the Lumsden minimum being 1,783 ω at 27 milliamperes.

THE INFLUENCE OF STRESS AND STRAIN ON THE PHYSICAL PROPERTIES OF MATTER.—PART III. MAGNETIC INDUCTION.*

BY HERBERT TOMLINSON, B A.

The author lays before the Society the results of experiments extending over a period of ten years on the effects of stress and strain on the magnetic permeabilities of iron, nickel, and cobalt. Two methods were employed. In one the metal to be tested—usually in the form of wire—was placed with its axis coincident with that of a magnetising solenoid, in most cases of considerable length as compared with the diameter of the wire; round the central portion of the solenoid was wrapped a secondary coil. A similar pair of primary and secondary coils, with a similar piece of the same specimen of metal, was balanced against the first by means of resistance coils, so that on closing the magnetising circuit no deflection was produced in a delicate Thomson galvanometer suitably connected up with the resistance coils and secondary coils. The alteration of magnetic permeability produced by stress was measured by the change necessary to be made in the resistance coils in order to restore the balance. In the second method the resistance coils were dispensed with, and only a metal core used in one of the two pairs of solenoids which were connected in series each to each. The arrangements were such that the pairs of solenoids, when without any cores, balanced each other's effects on the galvanometer, so that the deflections of the latter instrument were due only to the magnetic permeability of the metal to be tested. The alteration of permeability was in this case measured by the change of deflection produced in the Thomson galvanometer. The second method was the one principally employed. In all cases, where it is advisable, the results are either given in C.-G.-S. units, or data are supplied for reducing to these units; moreover, the author has endeavoured to separate, as far as possible, the effects of stress on the *permanent* and on the *temporary* permeabilities

* Paper communicated to the Royal Society by Prof. W. Grylls Adams, March 17th, 1887.

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of the metals,* which effects are for the most part opposite in nature. The paper is illustrated by a large number of curves showing the relations between magnetic permeability and stress and strain at different temperatures from 0° C. to 300° C. and upwards. The information conveyed by these curves it is impossible to adequately represent in an abstract, but the following are among the chief conclusions arrived at:—

1. When there is no permanent load on an iron wire, and the magnetising force is small, longitudinal traction of small amount increases the temporary permeability. The increase reaches a maximum very quickly, as the load increases when further loading begins to diminish the magnetic permeability until a certain limit has been reached, for which the permeability is a minimum. If the load be carried beyond the above limit the permeability begins to increase again with the load. As a consequence of the above, when the magnetising force is small there are *two* critical values of load for which the load produces no effect on the temporary permeability.

2. The first of the two critical values of loading mentioned above diminishes with increase of magnetising force, and finally vanishes when the latter reaches a certain limit. On the contrary, the second critical value of loading increases with the magnetising force.

3. The maximum of temporary permeability mentioned in 1 diminishes as the magnetising force increases, and occurs at a less and less degree of loading until the latter begins to produce decrease instead of increase of permeability. The minimum of temporary magnetic permeability, on the contrary, increases with the magnetising force; but, like the maximum, occurs with a lower amount of load the higher the magnetising force.

4. The effects mentioned in 1, 2, and 3 as being produced by loading are modified when a comparatively small load is left permanently on the wire. The modifications are stated in 5, 6, and 7.

5. For small magnetising forces loading produces no effect on the temporary magnetic permeability, unless carried beyond a certain limit. Beyond this limit further loading suddenly begins to increase the permeability.

6. For all values of the magnetising force the first critical value of loading vanishes. The second critical value of loading increases with the magnetising force, but for a given magnetising force is much lower than when there is no permanent load.

7. The minimum temporary permeability increases with the magnetising force up to a certain limit of the latter, but beyond this limit decreases.

8. The permanent magnetic permeability is increased by loading, the amount of increase per cent. being very large for small magnetising forces and moderate loads, but diminishing as the magnetising force increases.

9. The increase of permanent magnetic permeability mentioned in 8 rises in greater proportion than the load up to a certain limit of the latter. Beyond this limit it rises in less proportion than the load, and eventually ceases to rise with increase of load; the value of the load at which this last occurs decreases as the magnetising force is increased.

10. For a wide range of loading, the effect of the stress on the permanent permeability is opposite in direction to the effect on the temporary permeability. Consequently, loading may be found to produce either increase or decrease of permeability according as the permeability we are considering is temporary or permanent. Similarly the total magnetic permeability, since it includes both temporary and permanent permeabilities, may be effected by loading in the contrary direction to the temporary magnetic permeability, and the more so as the effects of loading on the permanent magnetic permeability are very much larger than those on the temporary magnetic permeability for a rather wide range both of loading and of magnetising force.

11. The effect of loading—even when carried to a great extent—on the temporary permeability of unannealed piano-steel is very small, provided the wire be not permanently stretched by the load.

12. The effect of loading on the magnetic permeability of annealed iron varies very considerably with the amount of previous strain to which the metal has been subjected.

13. When the magnetising force is very considerable and the load small, permanent extension, resulting from previous loading, causes the diminution of temporary permeability produced by the load to be much increased; also the maximum diminution which can be temporarily produced by loading is increased. When, however, the temporary load exceeds a certain limit, the diminution of temporary permeability produced by the load is lessened by permanent extension. Further, the load which produces maximum diminution of temporary permeability may be considerably lessened by permanent extension.

14. When the magnetising force is small the permanent strain may change *increase* of temporary magnetic permeability resulting from loading to *decrease*, provided the load does not exceed a certain limit. When the above-mentioned limit is exceeded the effect of the permanent strain is reversed.

15. The effects mentioned in 12, 13, and 14 are for the most part really the results of *subpermanent molecular strain*, and can be in great measure removed by severely shaking the wire.

16. The permanent molecular strain which is left on the removal of any load, produces, both for low and high magnetising forces, a permanent diminution of magnetic permeability increasing with the strain up to a certain amount of the latter. When, however, the strain is such that the wire is sensibly increased in length, the *temporary* permeability *increases* considerably, and the *permanent* permeability *diminishes* considerably up to a second limit of permanent strain, when once more *decrease* of temporary permeability sets in.

* By the terms permanent and temporary permeabilities are meant the permeability for permanent magnetisation, and the permeability for temporary magnetisation respectively.

17. The first maximum of the decrease of permeability mentioned in 16 at first decreases with increase of the magnetising force to nearly zero; it increases again, however, if we exceed a certain limit of magnetising force. On the contrary, the maximum increase of temporary permeability at first rises with the magnetising force until the permeability is more than doubled, when it begins to fall as the magnetising force is pushed further.

18. Mere rest after permanent extension has little or no effect on the alteration of the temporary permeability which is produced by loading, whereas it very perceptibly increases the longitudinal elasticity of iron.

19. For magnetising forces not exceeding a certain limit there are, for all temperatures between 0° C. and 300° C., two critical values of loading for which no alteration in the temporary permeability is produced by the load (*see* 1). The value of the load at the first critical point diminishes, and that at the second critical point increases, as the temperature is raised from 0° C. to 100° C.; but as the temperature is raised still further the first critical load becomes greater and the second becomes less, until at some temperature between 250° C. and 300° C. the two critical points coincide.

20. For magnetising forces exceeding a certain limit the two critical points of loading approach each other, at first slowly and then rapidly, with increase of temperature from 0° C. to 300° C. Both critical loads diminish with rise of temperature, but the second more rapidly than the first.

21. The effect of loading on the permanent permeability diminishes with rise of temperature from 0° C. to 300° C.

22. As the magnetising force increases, the total magnetic permeability of annealed iron which has not been previously magnetised rises to a maximum, and then begins to decline. The maximum permeability seems to occur at nearly the same point of magnetic *intensity* for different specimens of well-annealed iron of good magnetic permeability, but not at the same point of *magnetising force.*

23. When an iron wire has received previous magnetisation the point of maximum permeability occurs with a higher and higher magnetising force as the previous permanent magnetisation increases. The point of maximum permeability also occurs at a higher degree of magnetic *intensity* when the wire has been previously subjected to a high magnetising force.

24. Besides a point of maximum total permeability there is a point of maximum *temporary* permeability which occurs a little before the first-mentioned point.

(24 and 23 are in accordance with Maxwell's extension of Weber's theory.)

25. The temporary permeability is diminished by previous permanent or subpermanent magnetisation in the same direction. The effect above mentioned may be very considerable, provided the magnetising force lies between certain limits.

26. When the wire is well shaken after having been previously magnetised by a strong force, the temporary permeability is considerably restored, and is, moreover, much more nearly a constant for different values of the magnetising force than it was either previously to shaking or previously to suffering permanent magnetisation.

27. More than 90 per cent. of the whole magnetisation imparted by a given force to annealed iron may be permanent or subpermanent provided the magnetising force has a certain moderate value.* When, however, the force is very large the percentage of permanent magnetism is much diminished.

28. When an iron wire is loaded to a certain limit longitudinal magnetisation has no effect on the thermo-electrical qualities of the metal. The limit of loading mentioned above seems to be the same for a given magnetising force as that at which magnetisation has no effect on the dimensions of the wire.

29. The general features of the curves showing the relation between temporary magnetic permeability and load are the same for nickel as for iron.

30. There are two critical points of loading at which the load has no effect on the temporary magnetic permeability of nickel.

31. The load at the first critical point diminishes with diminution of the magnetising force, and finally vanishes. On the contrary, the load at the second critical point increases as the magnetising force diminishes.

32. The effect of increasing the magnetising force on both the first and second critical loads is therefore opposite in direction to the effect in the case of iron.

33 Similarly the effects mentioned in 3 are opposite in direction in nickel and in iron.

34. Rise of temperature from 0° C. to 300° C. increases the maximum increase of temporary magnetic permeability, which can be effected by loading nickel wire, and diminishes the maximum decrease.

35. With nickel, as with iron, the magnetic permeability is not constant, but reaches a maximum. The magnetising force which produces maximum permeability is greater with nickel than with iron, but the magnetic intensity at the point of maximum permeability is less with nickel than with iron.

36. Nickel wire can by shaking be more effectually demagnetised than iron.

37. Well annealed nickel is capable of retaining subpermanently a very large percentage of the whole magnetisation imparted. The maximum percentage retained is, however, not so great as with iron.

38. At a certain temperature the magnetic permeability of nickel vanishes. The temperature at which this occurs seems to be higher the

* This has been already noticed by Ewing (*Phil. Trans.*, 1885, Part II.), in whose important memoir other points of interest connected with magnetic induction which are mentioned in this paper have been also discussed.

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higher the magnetising force. This last, however, may perhaps be due to impurities in the nickel.

39. The magnetic permeability of nickel rises with the temperature to a maximum and then diminishes. The temperature at which maximum permeability occurs diminishes as the magnetising force increases.

40. The temporary effects of compression on the temporary magnetic permeabilities of iron, nickel, and cobalt, are in the opposite direction to the effects of extension, provided neither the mechanical nor the magnetic stress exceeds a certain amount.

41. The temporary effect of traction transverse to the line of magnetisation on the magnetic permeability of iron is opposite in direction to the effect of traction in the same line as the magnetisation.

42. Temporary torsion beyond a certain limit (*see* 44) increases the temporary magnetic permeability of iron. The amount of increase may become very large if the wire has previously suffered permanent torsion or permanent magnetisation in the opposite direction.

43. Permanent torsion decreases the temporary magnetic permeability. The amount of decrease may become very large if the wire has previously received permanent torsion in the opposite direction.

44. There is for all but very large magnetising forces a critical point of torsion, for which temporary torsion does not affect the temporary magnetic permeability.

45. When the critical point of torsion is passed, the temporary permeability increases with the torsion at first more rapidly than the torsion, and afterwards more slowly until a maximum is reached and the permeability begins to decline.

46. When the wire has previously suffered excessive permanent torsion, temporary torsion which has before produced increase of permeability now produces decrease.

47. The effect of temporary torsion on the temporary permeability of unannealed piano-steel wire is in the same direction as with annealed iron which has suffered excessive permanent torsion. (*See* 46.)

48. For a wide range of torsion the temporary permeability and the permanent permeability of annealed iron are oppositely affected by temporary torsion.

49. Fluid pressure does not temporarily affect either the temporary magnetic permeability of annealed iron, or the permanent magnetisation of hard steel, except, it may be, to a degree which is not comparable with that of the effect of stress applied in any one direction.

50. The application, however, or the removal of fluid stress like that of the stresses of compression, extension, and torsion, shakes out of annealed iron a certain amount of residual magnetism.

PHYSICAL SOCIETY.—March 26.

Prof. Balfour Stewart, President, in the chair.

Mr. Edmund van Aubel was elected a member of the Society.

The following paper was read: *On the Production, Preparation, and Properties of the Finest Fibres*, by Mr. C. V. Boys, M.A. The inquiry into the production and properties of fibres was suggested by the experiments of Messrs. Gibson and Gregory on the tenacity of spun glass, described before the Society on Feb. 12th, and the necessity of using such fibres in experiments on which Prof. Rücker and the author are engaged. The various methods of producing organic fibres, such as silk, cobweb, &c., and the mineral fibres, volcanic glass, slag wool, and spun glass were referred to, and experiments shown in which masses of fibres of sealing wax or Canada balsam were produced by electrifying the melted substance. In producing very fine glass fibres the author finds it best to use very small quantities at high temperatures, and the velocity of separation should be as great as possible. The oxyhydrogen jet is used to attain the high temperature, and several methods of obtaining a great velocity have been devised. The best results obtained are given by a cross-bow and straw arrow, to the tail of which a thin rod of the substance to be drawn is cemented. Pine is used for the bow, because the ratio of its elasticity to the density (on which the velocity attainable depends) is great. The free end of the rod is held between the fingers, and when the middle part has been heated to the required temperature, the string of the cross-bow is suddenly released, thus projecting the arrow with great velocity and drawing out a long fine fibre. By this means fibres of glass less than $\frac{1}{10000}$th of an inch in diameter can be made. The author has also experimented on many minerals, such as quartz, sapphine, ruby, garnet, feldspar, fluor spar, angite, emerald, &c., with more or less success. Ruby, sapphire, and fluor spar cannot well be drawn into fibres by this process, but quartz, angite, and feldspar give very satisfactory results. Garnet, when treated at low temperatures, yields fibres exhibiting the most beautiful colours. Some very interesting results have been obtained with quartz, from which fibres less than $\frac{1}{100000}$th of an inch in diameter have been obtained. It cannot be drawn directly from the crystal, but has to be slowly heated, fused, and cast into a thin rod, which rod is attached to the arrow as previously described. Quartz fibre exhibits remarkable properties, as it seems to be free from torsional fatigue, so evident in glass and metallic fibres, and on this account is most valuable for instruments requiring torsional control. The tenacity of such fibres is about 50 tons on the square inch. In the experiments on the fatigue of fibres great difficulty was experienced in obtaining a cement magnetically neutral, and sealing-wax was found the most suitable. An experiment was performed illustrating the fatigue of glass fibres under torsion, and diagrams exhibited showing that the effect of annealing them is to reduce the sub-permanent deformation to about $\frac{1}{10}$th its original amount under similar conditions. Annealing quartz fibres does not improve their torsional properties, and renders them rotten. Besides the use of quartz for torsional measurements the author believes that quartz thermometers would be free from the change of zero so annoying in glass ones. He exhibited an annealed glass spiral, capable of weighing a millionth of a grain fairly accurately, and also a diffraction grating made by placing the fine fibres side by side in the threads of fine screws. Gratings so made give banded spectra of white light. The author regretted that his paper was so incomplete, but thought the results already obtained would be of interest to the society. Prof. W. G. Adams congratulated the author on his most interesting paper, and considered the results to be of great importance. He believed the banded spectra exhibited by the grating were probably due to internal reflection within the fibres. Mr. Cunyngham asked whether the glass mirror used in the torsional experiments was magnetic, to which the author replied that this was probable, but even this assumption did not explain all the peculiarities observed.

A paper by Prof. Pickering was postponed till the next meeting, on April 23rd.

FOOTBALL.

Electrical Engineers F. C. (Hanover-square School of Telegraphy) v. Resistance F. C. (Messrs. Woodhouse and Rawson's Employés).

The above match was played at Balham on Saturday, April 2, and after a very fast and exciting game resulted in a draw. For the E E.F.C. Messrs. Purdom (captain), Collins, and Hartimans, as three-quarter backs, R. Monteath, as back, F. Webb, jun., and L. Monteath, as half-backs, and Messrs. Brown, Bradberry, and A. Webb, played a good game throughout. Messrs. Gush, Ruddock, Bush, Hewett, and Lumley played well for the Resistance F.C. One of the pupils from the Hanover-square School of Telegraphy took a photograph of the E.E.F.C. after the match.

THE ORIENTAL TELEPHONE COMPANY (LIMITED).

Report of the Directors for the year ended 31st December last, to be presented at the seventh ordinary general meeting of the Company, to be held at the City Terminus Hotel, Cannon-street, E.C., on Wednesday, the 27th inst., at one o'clock :—

After setting aside £3,634. 17s. 3d. in respect of the Indian guarantees to 31st December, the profit and loss account exhibits a balance to credit of £4,769. 11s. 3d., including £2,402. 15s. brought forward from 1885, the net profit for the past year being £2,366. 16s. 3d. It is not proposed to deal with this balance at present. The item £8,003. 18s., at credit of revenue account, includes a sum of £1,296. 6s., the amount of the Company's guaranteed interest on the preferred shares held by itself in the Indian companies. This sum forms part of the above-mentioned item of £3,634. 17s. 3d. carried to debit of profit and loss, so as to show the total amount of guaranteed interest due by this Company for the past year. Your Directors are glad to be able to announce that the guarantee to the Bombay Company will expire in September of the current year, and that to the Bengal Company in June following, after which the deferred shares of both these companies held by this Company will rank for dividend. The progress made by the Bombay Company during the past six months is encouraging, but the income of the Bengal Company is practically stationary. The local directors of these companies attribute much of the slow development in India to the obstructive and prohibitive policy of the Indian telegraph department. Your Directors recognise that this has been a serious obstacle to telephone enterprise in that country, and they have on several occasions represented to the Government of India, as well as to the Secretary of State for India at home, the injury that is being done to this enterprise by the action of that department; so far, however, they have been unable to obtain much redress. Their best efforts will still be made to procure the relief asked for. The returns from the exchanges worked directly by the Company have on the whole been satisfactory. The expenses at all stations have been reduced to a minimum, consistent with efficiency. The preferred shares held in the Telephone Company of Egypt have earned 6 per cent., as against 5 per cent. the previous year, and it is fully expected that the business of the current year will give equally good, if not better, results. The China Company, in which this Company has also a large interest, has been able to pay its interest on debentures, and reduce the deficit from former years' working, which it is hoped will be finally extinguished during the current year. The question of the Company's patents in Australasia has again occupied much of the time of the Board. Investigations into the position have necessarily been very slow; but your Directors fully expect shortly to obtain a recognition of the rights possessed by the Company. In terms of Article 66 of the Articles of Association, the Directors to retire at this general meeting are Mr. W. Addison and Mr. G. B. Frost. These gentle-

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men being eligible offer themselves for re-election. Messrs. Deloitte, Dever, Griffiths and Co., the auditors of the Company, retire, but offer themselves for re-election.

THE TELEPHONE COMPANY OF IRELAND.

Report of the Directors to be presented at the eighth ordinary general meeting of the proprietors, to be held at the offices of the Company, Commercial-buildings, Dame-street, Dublin, on the 15th inst.:—

The number of wires, exchange and private, under rental within the Dublin district and suburbs, upon 31st December, 1885, was 878. On 31st December, 1886, the number was 915. The business thus continues to show a steady and satisfactory progress. The heavy snow-storms and severe weather of the past winter caused no damage of any consequence to the Company's wires, and the whole system has again been peculiarly free from breakage or accidents. During the year the trunk lines to the principal suburbs around Dublin have been completed, and by offering exceptional facilities for the connection of the residences of subscribers with the Central Exchange, it is expected that the suburban business of the Company will be greatly developed. Trunk wires to other Dublin suburban districts will be erected as circumstances may justify the necessary outlay. In the month of April last an exchange was opened at Dundalk as an experiment upon the call-fee system, and the Directors are gratified to be able to announce that it has already developed sufficiently to pay its way. During the current year no doubt it will show a profit upon the working. Encouraged by the result of this experiment at Dundalk, the Directors have it now in contemplation to open exchanges in other towns upon the same system. In order to provide the capital necessary to meet the expenditure requisite for the increasing business of the Company in Dublin and its suburbs, and for the establishment of the proposed additional exchanges, the Directors consider it desirable that they should have the power of raising such capital by the issue of additional shares instead of by calling up the unpaid balance due upon the 29,776 preference shares partly paid, in the event of their deeming it desirable in the interest of the shareholders that such a course should be adopted at the time additional capital may be required. A resolution having that object in view will therefore be submitted to the meeting in the terms of the accompanying notice. The amount standing to the credit of net revenue account, including the balance of £98. 7s. 6d. brought from last account, amounts to £3,629. 2s. 4d., against £3,078. 16s. 10d. for the year 1885. Out of this sum there has been paid the interim dividend upon the preference shares for the half-year ended 30th June, 1886 (£779. 9s. 9d. paid in July last), also the interim dividend upon the ordinary shares (£656. 5s. paid in August), leaving an available balance of £2,193. 7s. 7d., as shown in the balance-sheet, since reduced, by payment (on the 14th January) of the dividend on the preference shares for the second half of the year, to £1,355. 4s. 8d. This would permit of the payment of an increased dividend on the ordinary shares at the rate of 1½ per cent. for the second half of the year, as against ¾ per cent. for the corresponding half of 1885; but the Directors think it more prudent to substantially strengthen the reserve fund. They therefore propose to allocate the balance as follows:—For the payment of a dividend on the ordinary shares at the same rate as for last half-year—namely, ¾ per cent. per annum, £656. 5s., and to place to the credit of the reserve fund £369. 18s. 3d. (being 10 per cent. upon the net profits of the year), carrying forward the balance of £329. 1s. 5d. to credit of the current year, as against £98. 7s. 6d. brought in from 1885. In conformity with the Articles of Association, Mr. E. Dwyer Gray, M.P., chairman, and Mr. Arthur Dudgeon retire at this meeting, but, being eligible, they offer themselves for re-election. The auditor, Mr. John M. Kean, also retires at this meeting, but offers himself for re-election.

CITY NOTES.

ANGLO-AMERICAN TELEGRAPH COMPANY.—The Board of Directors of the Anglo-American Telegraph Company has resolved to declare an interim dividend for the quarter ended March 31, 1887, of 5s. per cent. on the ordinary stock and 10s per cent. on the preferred stock, less income-tax, payable on May 2, to the stockholders registered on the books of the company on March 31, 1887.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of March was 4,775, estimated to produce £3,650, against 3,944 messages, producing £3,345, in the corresponding month of last year. The traffic receipts for the month of December, estimated at £3,100, realised £3,125.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of March amounted to £1,850, against £1,760 in the corresponding period of last year.

DIRECT UNITED STATES CABLE COMPANY.—The Board of the Direct United States Cable Company has resolved upon the payment of an interim dividend of 2s. per share, free of income-tax, being at the rate of 2 per cent. per annum, for the quarter ending March 31, 1887, such dividend to be payable on and after the 23rd inst.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for March amounted to £49,797, and to £53,016 in the corresponding period of 1886.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of March, 1887, amounted to £38,177, and to £37,804 in the corresponding period of 1886, being an increase of £373.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for March amounted to £21,600; for the period from 1st January to 31st March to £61,200. For corresponding months of 1886 they amounted to £58,680, and for 1885 to £64,400.

SUBMARINE CABLES TRUST.—Notice is given that a payment of £1 10s. will be made on account of the coupon, due on the 15th inst., on and after that date by Messrs. Glyn, Mills and Co., of Lombard-street, between 10 a.m. and 2 p.m. The coupons must be left with the bankers for examination five clear days previous to calling for payment. They will be stamped with the words "£1 10s. paid," and returned to the holders. The trustees announce that the report and accounts for the financial year ending 15th inst. will be issued early next month.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 31st March are £3,216, as compared with £3,263 in the corresponding period of 1886. The December receipts, estimated at £5,296, realised £5,311.

CADOGAN ELECTRIC LIGHT COMPANY (LIMITED).—This company was registered on the 21st inst., with a capital of £30,000 in £5 shares, to enter into contracts for electric lighting, and for the supply of electric energy. The subscribers are:—

	Shares.
J. Sayer, 25, Norfolk-road, Brighton, engineer	5
B. Verity, jun., 137, Regent-street, gas engineer	5
S. Haynes, 60, Fernlea-road, Balham, gas engineer	1
J. W. Humphrys, Boston-road, Hanwell, clerk	1
C. J. White, 36, Knowle-road, Brixton, newspaper proprietor	1
T. Fawkes, 33, Denzil-road, Neasden, brassworker	1
W. Webb, 11, Austinfriars, solicitor	1

The number of directors is not to be less than three nor more than five; qualification, 100 shares; the subscribers are to appoint the first; remuneration, £150 per annum.

DANIEL JUDSON AND SON (LIMITED).—At the second ordinary general meeting of this company, held at the Guildhall Tavern, the chairman (Mr. E. E. Harding), in moving the adoption of the report (which recommended a 5 per cent. dividend), announced that the company had added to their business a branch for the manufacture of certain electrical apparatus, such as bells, medical coils, pushes, &c. They had also obtained the patents for the manufacture of corrugated carbons, for which they had during the last few months experienced a continuously increasing demand.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. April 5.		Business Done Week Ending April 5. Highest.	Lowest.
Anglo-American	35,	36	37⅞	35
Do. Preferred	56,	57	58½	56½
Do. Deferred	14,	15	15⅝	14¼
Brazilian Submarine	10⅝,	10¾	10 13-16	10¾
Cuba	11½,	12	—	—
Do. Preference	18,	19	—	—
Direct Spanish	2¾,	3	2⅞	2½
Do. Preference	7,	8	—	—
Direct United States Cable	9,	9½	9½	9⅜
Eastern Telegraph	10¾,	11	10 15-16	10 11-16
Do. 6 per Cent. Preference	13,	14	14	13⅝
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	11⅞,	12⅜	12⅜	12
German Union	8¾,	9¼	9⅜	—
Globe Telegraph and Trust	5⅜,	5⅝	5⅝	5½
Do. Preference	12½,	12¾	—	—
Great Northern	13¾,	14	14	13⅞
Indo-European	35,	36	—	—
Reuter's	6¾,	7¼	—	—
Submarine	180,	190	—	—
West India and Panama	⅝,	⅞	¾	—
Do. 1st Preference	9½,	9¾	—	—
Western Brazilian	7,	7¼	7¼	7 3-16
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¼,	⅜	—	—
Oriental	3-16,	5-16	—	—
United Telephone	12¼,	12¾	—	—

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	—	—
Do. (fully paid)	3¾,	4¼	4 3-16	—
Swan	1⅜,	1⅝	1 9-16	—
Maxim Weston	3-16,	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	35,	37	36½	35
India Rubber, Gutta Percha, and Telegraph Works	22,	23	—	—

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NOTES.

GLASGOW. — Telephonic communication was established between Glasgow and Dunfermline for the first time on the 8th inst.

THE LATE PROFESSOR FLEEMING JENKIN.—It is stated that Mr. R. L. Stevenson is engaged upon a biography of the late Prof. Fleeming Jenkin.

PARIS.—An extensive electric lighting plant is now being fitted up at the Opera Comique, where about 1,700 lamps will be employed. The work is being carried out by the Edison Company.

"THE STORAGE OF ELECTRICAL ENERGY."—Mr. Paul Bedford Elwell will publish shortly, through Messrs. Whittaker and Co., his translation of Gaston Planté's work on "The Storage of Electrical Energy."

THE BLACKMAN AIR PROPELLER.—We understand that at the Stock Exchange the Blackman air propeller is being tried for the ventilation of the building. The propeller is driven by a small electric motor, supplied with current from the secondary batteries used in the lighting.

AMSTERDAM.—It is stated that negotiations are in progress between the respective Governments with a view of extending the Paris-Brussels telephone line as far as Amsterdam. In that case it is to be presumed that Antwerp, and perhaps Rotterdam, will also be included in the circuit.

ROYAL INSTITUTION LECTURES.—The Tuesday afternoon lectures at the Royal Institution on April 19th, 26th, May 3rd, and 10th, will be delivered by Dr. John Hopkinson, on the subject of "Electricity." On Friday, May 13th, Prof. J. S. Burdon Sanderson lectures on "Some Electrical Fishes."

ELECTRIC LIGHT AND PHOTOGRAPHY.—The New York illustrated paper, the *Daily Graphic*, has adopted the American arc lighting system (which is practically the same as that known in this country as the Maxim-Weston) in order to be in a position to meet the demands of rapid pictorial work.

THE GAIETY THEATRE.—A few evenings ago the hundredth representation of "Monte Cristo" was celebrated at this theatre by a supper and dance, the stage, &c., being illuminated and decorated for the occasion by the electric light, the arrange ment of which was carried out by Messrs. E. L. Berry and Co.

THE BRUSSELS 1888 EXHIBITION.—The King of the Belgians has nominated M. Rousseau, Professor of the University of Brussels, as President of the Electrical Section of the above Exhibition. M. Rousseau filled a similar office at the Antwerp Exhibition in 1885. M. Gody and M. Nothomb are appointed secretaries to the section.

INDIAN MILITARY TELEGRAPHS.—The Indian Government has adopted the proposals of a committee which has recently reported upon the question granting relative military rank to civilians engaged in the telegraph service of an army in the field. A signaller is to rank as a corporal, a superintendent as an assistant field engineer.

STORAGE BATTERY LITIGATION IN THE STATES. — The Electrical Accumulator Company, of New York, has entered in the United States Circuit Court, at Cleveland, Ohio, two suits, which are practically one in aim, against the Brush Electric Company for alleged infringement of patent. The New York company sues upon the Faure patents.

A CURIOUS POINT.—Dr. Louis Duncan, of the John Hopkins University, has pointed out that the loss of power by hysteresis in the reversal of magnetisation of iron is less in the case of the armature of a dynamo than in that of the case of a transformer, because in the former case the reversals are assisted by the vibration of the machine in driving.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The sixty-fifth number of this Society's *Journal*, which has just made its appearance, contains the inaugural address of the new President, Sir Charles Bright, and the paper on "Telephonic Investigations," by Professor Silvanus Thompson, together with the interesting and important discussion, extending over three evenings, by which it was followed.

THE GERMAN POST AND TELEGRAPH EMPLOYÉS.—The officials and *employés* belonging to the German Post and Telegraph Offices recently collected among themselves the sum of seventeen thousand marks for the purchase of three lifeboats, to be placed at the disposal of the German Society for the Rescue of Shipwrecked Mariners, and the gift has just been acknowledged by a cordial letter of thanks from the Emperor.

THE ELECTRIC LIGHT ON THE CONGO.—A missionary steamer which is about to leave New York for Stanley Pool, on the Upper Congo, is taking a complete outfit of electric lighting plant, supplied by the Fuller-Wood Electric Light Company. Some further particulars as to the character and purpose of this installation would have been interesting, but at present our information extends no further than above given.

THE SOCIÉTÉ INTERNATIONALE DES ELECTRICIENS.—At a meeting of this society, held at Paris on the 6th inst., M. E. Mascart was nominated as president for the year 1887, and M. Seligmann-Lui as secretary. In recognition of the services rendered by the retiring president, M. Maurice Lœwy, especially in the organisation of the laboratory of the society, it was unanimously determined to confer upon M. Lœwy the title of Honorary President.

THE BRISTOL-CARDIFF TELEPHONE LINE.—The Western Counties and South Wales Telephone Company have now completed the line between Bristol and Cardiff, and the working proves to be everything that could be desired. The completion of the line, which is sixty-six miles in length, has been much delayed owing to the severe weather of the last few months. A full description of the construction and route adopted will be found in our issue of January 7 last.

THE "AIR SPACE."—Last week we mentioned that an American electrician had suggested the use of the term "Annulus;" two more suggestions now come to hand from the same quarter. These are "inter-field" and "kinetic-field." "Field," says the author of the latter proposal, "suggests space and kinetic denotes active energy, thus 'field of active energy,' embracing both the space occupied by the wire of the armature and the clearance space between it and the field-magnet."

THE LIGHTING OF THE "FREEMAN'S JOURNAL" OFFICES. In reference to a recent note on the electric lighting of the offices of the *Freeman's Journal*, at Dublin, the editor of that paper informs us that our information as to a breakdown of the installation having been caused by malicious short-circuiting is not (within his knowledge) correct. In justice, therefore, to the person or persons unknown who did *not* short-circuit the dynamo we are happy to make this correction.

SUBMARINE CABLES.—We are informed that the repair of the West African Telegraph Company's cable has been successfully accomplished, and that messages for St. Paul de Loanda can now be forwarded as usual.—We are requested to state that interruption in the cable between Chorillos and Mollendo does not affect the *direct* communication between this country and the Argentine Republic and Uruguay, which of course remains open *viâ* the direct line of the Brazilian Submarine Telegraph Company.

BOURNEMOUTH. — On Monday last Messrs. Shepherd, Mortimer and Co. commenced the illumination of the pier at

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Bournemouth with 15 arc lamps. It is intended shortly to replace these with incandescents, in order to give the Bournemouth people the opportunity of deciding which system they prefer. The current is furnished from a station in Orchard-street, where a 100 horse-power engine has been erected, and Messrs. Mortimer and Shepherd hope to do a good deal of private lighting from this centre.

THE TELEPHONE IN CHINA.—The *Standard* of April 13 contained the following paragraph:—"The Chinese Minister, having been recently much impressed with the exhibition of the long-distance telephone as a rival to the telegraph, two parties of electricians have since undertaken to produce similar results in China. The Philadelphia capitalists expect that this will result in important concessions. The first party of electricians sailed for China in the 'Hampshire' from San Francisco on March 19; the second will follow on April 20."

PROPOSED TELEPHONIC COMMUNICATION BETWEEN PARIS AND LONDON.—The visit of M. Granet to Brussels has given rise to a rumour that the French Minister is consulting M. Mourlon (the indefatigable representative of the Van Rysselberghe system) with a view to establishing telephonic communication over one of the existing submarine cables between Paris and London, and, of course, without interfering with the use of the cable for telegraphic purposes. It may, however, be wiser to try one thing at a time; let us get a telephone cable, pure and simple, down first, before we think of doubling the service.

ACTION FOR INFRINGEMENT OF THE GAULARD AND GIBBS PATENT IN AMERICA.—The Westinghouse Electric Company entered an action against the Sun Electric Company, of Portland, Me., March 15th, in the United States Circuit Court, at Boston. The suit is based upon alleged infringement by the defendant company in the State of Massachusetts of the Gaulard and Gibbs patent of October 26, 1886, upon distribution by secondary generators. The Sun Electric Company is alleged to be doing business in Woburn, Mass. On reference to our advertisement columns it will be seen that similar litigation is in course of progress in this country.

THE FIRST USE OF THE NAME TELEPHONE.—According to Mr. Lockwood, the earliest use of the word *telephone* occurs in Timbs' "Year Book of Facts in Science and Art for 1845," in connection with an invention of a certain Captain Taylor, for signalling at a distance by means of compressed air forced through trumpets. The well-known experiments of Prof. Wheatstone on the transmission of musical sounds by means of a single rod of wood date back to the year 1821; but although these experiments are far more intimately connected with the modern developments of telephony than those of Captain Taylor, the term does not appear to have suggested itself to Wheatstone.

MEXICO.—We stated in October last that seventeen electric clocks were about to be erected in the City of Mexico by the municipal authorities. We regret to learn that the innovation does not appear to have been altogether a success. A local paper comments as follows:—"The famous electric clocks set up in different parts of the city by the municipal council cost a good round sum, and are very ornamental in their wooden towers; but unfortunately they do not keep time. The clocks should either be kept in running order or replaced by others that can be relied on, even if of the old-fashioned sort. It is all very well to keep up with the time by introducing the latest useful inventions, but if the inventions are found on trial not to be useful there is nothing to be gained by clinging to them."

A SINGULAR DEVELOPMENT OF THE TELEGRAPH SYSTEM. The success of the Delany Multiplex Telegraph has led, in the United States, to the introduction of a novel system of telegraphs, termed leased lines. The first undertaking of this description will shortly be opened between New York and Boston. A line of twenty wires has been erected, and each wire will supply about a dozen circuits. The individual circuits will then be leased out as private lines. But, as competition in telegraphs is free and unrestrained in the States, it is anticipated that many of the wires will be rented by telegraph operators who will start business on their own account, "hoping by strict attention to business to merit a share," &c., &c. For the sake of the operators, who have not at present much to look forward to in life, it may be hoped that the system will prove a success.

THE BERLIN TELEPHONE EXCHANGE.—According to the official returns the subscribers to the Berlin Telephone Exchange take advantage of the facilities afforded them to an extent unexampled elsewhere, the average number of messages sent by each subscriber being about 22 per diem, as compared with 5 in London and 8 in New York. The number of subscribers exceeds 6,000, the largeness of the number being partly due no doubt to the amount of the annual subscription being £7. 10s. only, and also to the endeavours of the officials to meet the requirements of subscribers. The replacement of the old magneto-transmitters by microphones has now been almost completed. The authorities have recently decided to connect the fire engine and police stations with the general telephonic system, as it is generally found that in the case of an outbreak of fire no one knows where to find the fire alarm telephones.

THE TELEPHONE IN FRANCE.—From an article in *La Semaine des Constructeurs* it would seem as if a solution of the question of low rates on telephones might be realised in France ere long. At present there are in France two telephone systems. One system is managed by a company whose charges are $120 per annum in Paris, and $80 outside of the capital. The other system is controlled by the State, which charges $40 per annum plus a certain percentage of the cost of the lines. The charter of the company expires in 1887, and it is proposed to form one company with a capital of $20,000,000, one-fourth stock and three-fourths bonds, to be used in buying up the existing lines and building new lines. The State is to become owner of the whole plant as soon as it is in working order. The company asks for a monopoly of the business for thirty-five years. The income to be applied first to paying off the capital; the State to have 15 per cent. of the profits; the State to control all construction and management; all *employés* to be naturalised Frenchmen, and to be sworn to professional secrecy; the tariffs to be lowered in proportion to the income; the State to have the right to buy up the charter after fifteen years.

WINCHESTER.—The Special Lighting Committee of the Winchester Town Council reported, at their meeting on the 7th inst., that they had fully considered the question, and investigated the relative advantages and cost of lighting the city by gas, oil, and electricity, and had arrived at the conclusion that the lighting of the principal streets by electricity, and the remainder with oil, would be more efficient than the general adoption of gas lighting with improved burners. The committee had received an offer from Messrs. Laing, Wharton, and Down to the effect that, in consideration of the Council entering into a five years' contract, they would be prepared to put down the necessary generating plant at a central station, to supply all

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the necessary circuits, lamps, &c., and leads complete, and light and maintain from dusk to daylight throughout the year any number of arc lamps exceeding 20, on the Thomson-Houston system of 1,200 candle-power each, for the sum of £22 per annum for each lamp. The committee submitted two schemes—one to cost £1,299; the other £1,900—and recommended the former. The present cost of lighting is £884. A discussion arose on the recommendation; but the further consideration of the matter was adjourned.

PHILADELPHIA.—The annual report of the Chief of the Electrical Department of the City of Philadelphia states that at the opening of the present year there were 5,053 poles on the city highway, besides those for railroad use and those belonging to the city, and 4,490 miles of telegraph and telephone wire. The whole amount of conduit laid in the city is 19,963ft., and the amount of wrought-iron pipe, 1¼in. and 2in., through which single wire was drawn, was 21,347ft. During 1886, 250 permits were issued for poles, wires, and repairs, but only for the extension of electric light service already authorised. At the close of 1886 there were 354 electric lights; 156 having been placed during the year. The average cost of their maintenance has been 53⅞ cents. per night; 737 lamps have been displaced by these electric lights. The report reiterates the recommendation made at the close of 1885 that these lights be extended to the entire city, and now adds the recommendation that the city should own its plant for the purpose. There are now in the city 389 fire-signal boxes, 36 having been added during the year, and it is recommended to increase the number to at least 500. The city and county are using 247 telephones. The number of police wire messages transmitted was 235,680. The number of fire alarms was 466. There are now in use in the city 4,000 arc lights and 20,000 incandescent lights.

ELECTRIC LIGHT ON THE U. S. RAILWAYS.—The lighting of railway carriages in the United States seems likely before long to open up an extensive field for the employment of accumulators. An American journal says:—"The Boston and Albany Company, having had a passenger car in service lighted with the electric light, has decided, it is said, to equip a large number of cars in the same way. The trial car (and the others are to have substantially the same apparatus) carries 24 incandescent lamps of 16 candle-power each, the power for these lamps being furnished by a Jullien storage battery carried underneath the car. This storage battery will keep all the lights burning for 10 hours; it has 60 cells, each cell consisting of 19 plates, weighing in all 27lb., and measures 6½in. by 5¾in., and 8in. high. These cells are combined in boxes for convenience in carrying and changing, and the whole battery weighs about 1,800lb. The car is lighted brilliantly, and in ordinary service a smaller number of lights would be sufficient. In a month's service there has been no trouble whatever with the lights, and it is claimed that the work necessary to recharge the batteries is much less than that required to take care of lamps, while the cost is no greater. The apparatus was furnished by the Jullien Electric Light Company, of New York, which owns the patents covering the Jullien storage battery in this country. That company is equipping cars for the Baltimore and Ohio, the New York Central, and the Pennsylvania roads, and the new system is to have a trial on all those lines."

SOME INTERESTING EXPERIMENTS WITH STATIC ELECTRICITY.—The following interesting experiments, which will probably be new to many of our readers, were described by Mr. Boys at a recent meeting of the Physical Society:—"If sealing wax, or any similar sticky substance, be melted in a cup and put upon the conductor of an electrical machine, as in one of the old fashioned experiments, it will begin to throw out threads in an extraordinary way; the fibres are large when the resinous matter is very hot, each fibre shoots out as a cylinder with remarkable speed, then breaks into beads. These minute beads can be made to patter against a drum head, and make a noise upon it like falling rain. The cup containing the melted wax should be inclined from the operator and from the electrical machine before the latter is worked, or both will be covered with the most invisible sticky web imaginable; a cup of burnt india rubber tubing so treated sends out almost invisible filaments. Canada balsam is the perfection of a material for producing such sticky threads. When a candle is held near a cup throwing out such electrified filaments, they shoot into the flame, and sometimes cover the candle; sometimes they will stop as they approach the flame, then turn back, and go into the cup from which they started, in consequence of discharging their electricity into the flame. In a few minutes miles of these sticky threads can be made, and as they break into beads the method affords a ready means of powdering such of these substances as are not easily pulverised in any ordinary way."

BERLIN.—During the recent illuminations in celebration of the birthday of the Emperor of Germany electricity played a very prominent part. The various electric lighting companies in Berlin took care that their own buildings should not present the least brilliant spectacle offered to the crowds of sightseers. The Edison Company, which has a central station in the Frederick-Strasse, illuminated the exterior of the buildings with many hundreds of lamps of different colours. In a central window a colossal bust of the Emperor surrounded with palm and laurel wreaths was skilfully and effectively illuminated by lamps that were not themselves visible, and undoubtedly produced one of the most novel and successful illuminations in the whole city. The "Staedlische Elektricitätswerke" is not so fortunate as the Edison Company in possessing a frontage in a main thoroughfare; the company, however, availed themselves of the opportunity of lighting the towers of the two churches at either end of the Gensdarmer Market, and surrounded each clock with a dozen arc lamps, producing a total illumination estimated at 200,000 candles. The house of Siemens and Halske distinguished themselves by the originality of their ideas. A gigantic W, formed of 15 arcs, was suspended across the street in front of their premises at a great height above the roofs of the houses, an arrangement which produced a most striking effect. The rain, which unfortunately fell during the evening, had at least the advantage of affording a demonstration of the superiority of electric lighting for outdoor illumination, not a few of the gas and oil lamps being extinguished.

THE AMERICAN BELL TELEPHONE COMPANY.—According to the annual financial statement of the American Bell Telephone Company, the gross earnings for the year ended 31st December, 1886, amounted to $3,097,000, or $331,000 more than the year before. The expenses amounted to $1,149,717, leaving the net earnings $1,947,283, or with the addition of miscellaneous credits amounting to $26,067, $1,973,350. The regular and extra dividends paid, amounting to 16 per cent on the capital of $9,802,100, took $1,568,336, and after reserving $117,754 for depreciation, there remained to be added to the surplus $287,260. The surplus account at the end of the year was $1,491,380. During the year 1886 the number of telephone subscribers increased from 137,750 to 147,068, the number of miles of wire in use from 114,646 to 128,231, and the number of instruments in the hands of licensees from 330,040 to

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353,518. The stocks (in other companies) owned by the Bell Company are reckoned on the books at $22,605,925. The average number of daily calls per subscriber throughout the United States was 5·82 in 1886, as against 5·43 in 1885, indicating increasing use for the invention. The company proposes to "incur heavy outlays for underground wire work." It is intimated, however, that this and other increases of facilities cannot be afforded if the price of telephone service is to be fixed by law. The number of miles of wire underground was nearly doubled last year, but stands now at only 6,000 miles, as against 10,900 miles on buildings and 111,300 miles on poles. The large profits of the Bell Company induced the Massachusetts Legislature last winter to increase its tax levy, and the amount collected in 1886 in that State was $74,800. In Canada business and profits are said to be increasing, notwithstanding the nullification of the Blake transmitter patent, as well as the Bell patents.

OBITUARY.—DANIEL DAVIS.—On Tuesday, March 22, 1887, there died on his farm, at Princeton, Mass., one who, 40 years ago, was far ahead of his time as a professional electrician and electro-mechanician. We refer to Mr. Daniel Davis, long a manufacturer of and dealer in electrical apparatus at Boston. He was born in Princeton, March 8, 1813. Mr. Davis made much of the earliest telegraph apparatus for Morse, and in his shop also, it may be noted, was made by Elias Howe one of the earliest sewing machines. The business which he organised is still carried on in Bromfield-street, Boston, by Thomas Hall. He will, however, be best remembered through his work on magnetism, entitled "A Manual of Magnetism, including Galvanism, Magnetism, Electro-Magnetism, Electro-Dynamics, Magneto-Electricity and Thermo-Electricity." It contained about 180 original illustrations. The first edition came out in 1842, but it ran through several editions, and is now out of print. Originally published more to advertise the wares of Mr. Davis, and as a means of calling attention to his business, than as a text-book of electro-technics, its value as a *vade mecum* of electrical information was at once seen. The first edition of 1842, and the second edition, which was published in 1847, were both written under the supervision of Drs. John Bacon, jun., and William F. Channing, and hence acquired an elegance of style and a perspicuity of language, which, combined with the practical knowledge of Mr. Davis, assured the success of the book. It was adopted as a text-book by many colleges and high schools in the United States, becoming a great favourite especially in the Military Academy at West Point, for the sake of the many practical demonstrations shown within its pages. It has become extremely scarce, but it has ever been valued by those fortunate enough to possess a copy of it, and even now many of our ablest electricians are not ashamed to confess that they have learned much from Davis's "Manual of Magnetism." Mr. Davis was a friend of Charles Grafton Page, and made a number of experiments with him up to 1839, when Dr. Page went to Washington.—*New York Electrical World.*

THE GIMÉ INCANDESCENT LAMP.—When the incandescent light is introduced into a private residence it is nearly always found desirable to take some steps in order to avoid the dazzling effect which results from gazing on the glowing filament or bulbs. As a rule some kind of ornamental shade is placed over each lamp, and usually intercepts a large fraction of the light. Lamps are also made with ground glass bulbs, but this is open to the same objection, and such lamps are also, comparatively speaking, costly. A less expensive plan, and one which gives rise to a very pretty effect, has recently been employed in Germany, and consists simply in dipping the lamp bulbs into a solution of some salt, such as nitrate or sulphate of soda, which readily crystallises upon the glass. An even better plan (of which a description was given in our columns last week) is to cover the globes with a varnish specially prepared for the purpose. M. Gimé (who is, we believe, electrician to the Julien Power Storage Company, of Brussels) has, however, brought out a lamp in which the difficulty in question is overcome in an entirely different way. According to the description before us the lamps made by M. Gimé are filled with hydrogen at such a pressure that the gas exists in the radiant state. The filament of the lamp is said to be composed of an entirely new material disposed in such a way that radiant discharge takes place within the bulb, and the filament is surrounded with a luminous aureole, by which its outline is obscured, the whole bulb being filled with soft diffused light. We have not yet had an opportunity of examining one of these lamps, and the precise nature of the arrangement is not quite clear from the description given. It is difficult to understand how anything in the nature of a Geissler tube effect can be obtained at the potential of 100 volts. It is, however, claimed that a 100 volt Gimé lamp, of 25 candles, absorbs the same energy as the Edison 100-volt lamp of only 16 candles. As to the question of anticipation or infringement, M. Gimé appears (like every other inventor) to have perfect confidence in the inviolability of his position. He (or his agent) somewhat naïvely remarks that they have been waiting for the close of the recent litigation in this country in order to have an opportunity of picking up cheap a little mercury, and a few pumps, muffles, &c.

THE NEW ORLEANS TOWERS.—We recently stated that the city of New Orleans had decided to adopt and enforce Col. Flad's suggestion for overcoming the wire difficulty by the erection of tall towers at the street corners, carrying all wires high above the roofs from tower to tower. An ordinance issued by the City Council sets forth that since the whole present system of running wires on poles is a danger and a nuisance, a special right for fifty years has been given to a contractor (Mr. Maurice Hart) to erect in the streets, &c., a system of towers or supports for the purpose of carrying all wires and cables, whether for telephone, electric light, telegraph, or other electrical purposes, under the supervision of the Commissioner of Public Works. The lower wires are not to be less than 10ft. above the roof of the buildings near which a tower is located. The towers are to be divided into sections, each section being devoted to a special class of wires. The contractor is given the right to fix a price not exceeding $500 per mile for a horizontal section or division of 3ft. by 5ft. upon every tower and support within the said mile, for occupation by not more wires or cables than shall together amount to the weight of 100 No. 10 wires American measurement, and no person shall claim or demand any right to have a less price for a smaller space or less weight The contractor is to pay the city 5 per cent. of the annual profits of the business, to provide free of charge fire hose or pipes run up on each of the towers, and to allow the city to use the towers for all its own wires without cost. It is further provided that any electric light company now or hereafter having the right to put up lamps shall be empowered to place lamps on the towers at an annual rental not to exceed $5 per lamp. The companies owning pole lines are to remove them. It will be seen from this abstract that a new departure of very considerable importance has been made, and unless unforeseen difficulties arise it may be taken for granted that the example of New Orleans will be widely followed in the American towns. The chief trouble will probably be found in the length of the spans, especially for electric lighting cables. The necessary increase in the length of many of the circuits

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will also be a source of annoyance to the companies. A contract has already been placed with the Star Iron Tower Company, of Fort Wayne, Ind., for 224 towers.

THE ELECTRIC LIGHT IN INDIA.—A correspondent at Bombay sends us an account of the electric lighting in some of the Indian cities during the illuminations in honour of Her Majesty the Queen's Jubilee on the 16th of February, as follows:—At Hyderabad (Deccan), Jablochkoff lights, with Gramme's alternating current machines, and Brush machines. At Morvi (Kattyawar), Jablachkoff lights and Gramme's machines. At Indore (Central India), Brush machines. At Calcutta, two Gramme A type machines, with Gramme's 5,000 candle-power lamps. At Rangoon, Jablochkoff and Brush, &c. At Bombay, the Yacht Club had a Brush compound-wound machine working 300 Swan and Edison lamps; the Clock Tower had also incandescent lamps on the spire, and the windows and clock, painted light green, lit up interiorly by Brush lamps, presented a very pretty moonlight effect. However, the great feature of electric lighting was centered in the immense pile of the new "Victoria Terminus," the grand building constructed (and nearly finished) for the Great Indian Peninsula Railway, probably the finest railway station in the world. The display of electric lighting from the variety of systems employed is probably unique in the annals of electric lighting of the outside of a single building. Twenty-six Brush lamps were arranged along the façade and on the top of the dome, and on some of the cornices; ten Jablochkoff lamps lit up the south façade; one 5,000 candle-power Jaspard lamp, with a reflector at back, fed by an A type Gramme machine, was placed on the summit of the cupola; one hand Dubosq lamp in a Col. Mangin's projector, fed by an A type Gramme machine, threw a strong ray of light on the animated groups below, on the passage of the Governor with T.R.H. the Duke and Duchess of Connaught. The ray of light was projected all the time in front of them, lighting up like daylight the procession of carriages of all kinds, and the immense crowds which lined the roads. Finally, "Victoria Terminus," in letters 6ft. high, was designed by 250 Edison 16 candle-power incandescent lamps, fed by four American Edison Z machines. The whole lighting was done with three portable steam engines, two Brush, and two Gramme machines (one constant and one alternating current), and four Edison machines. Unfortunately, on account of want of time, the incandescent light installation was not quite complete, and was only lit up on the 17th. The entire work, mechanical and electrical, was done by native hands, under the superintendence of Mr. Fischer, of the Indian Electric Light Company.

STREET LIGHTING IN NEW YORK.—The report of the Superintendent of Lamps and Gas of the City of New York for the year ending Dec. 31, 1886, shows that the total expenditure for "lamps, gas, and electric lighting" amounted to $712,488. The lighting of the public lamps cost $639,096, which was distributed as follows:—Gas lamps $456,465, electric lamps $180,420, naphtha lamps $2,211. The gas lamps on Manhattan Island, which are supplied by the Consolidated and New York Mutual Companies, cost $17.50 each per annum, while those of the Equitable Company cost $12. Beyond the Harlem River, the Central Company is paid $28, and the Northern and Yonkers Companies $30 per lamp. The electric lamps cost 70 cents. each per night, or $255.50 each per annum. The United States Illuminating Company furnish 363 lamps, and the Brush Electric Illuminating Company 348. The total aggregate length of streets which were lighted by electric lights on December 31 was 30 miles, to which must be added about 42 acres of public parks, &c. The report contains one very interesting table, in which a comparison is made between the number and cost of the electric lights now in use and the number and cost of the gas lamps which were replaced. There are 711 electric lamps, which have replaced 3,211 gas lamps, so that each electric lamp is equal to 4½ gas lamps. It appears, however, that the 711 electric lamps cost $125,468 more than would have been paid if the streets had been lighted by the gas lamps. A tabular statement is appended to the report, in which is given the streets which the Aldermen have requested the Gas Commission to light by electricity, together with the estimated number of electric lamps required and their cost, and the gas lamps which would be replaced by the change. If all these substitutions were made it would require 2,123 electric lamps at a cost of $542,426.50. They would replace 5,385 gas lamps, and the expense of maintaining the electric lamps over and above that of the gas lamps would be $446,299. The total number of lamps on December 31st was 24,194, besides which there were 120 naphtha lamps and 711 electric lights, making a total of 25,025.

THE MAGNETISATION OF IRON IN STRONG FIELDS.—At a meeting of the Royal Society on the 24th ult, Sir William Thomson communicated a paper on this subject by Prof. J. A. Ewing and Mr. William Low. The experiments described by the authors were undertaken with a view to determine what is the maximum induction which iron is able to take. Hitherto an induction of about 24,000 lines per square centimetre (or with some doubt as to the accuracy of the observation one of 26,000) is the highest figure yet recorded, and in practice in the armatures of dynamos or the cores of transformers the induction has seldom exceeded 20,000 lines. It has now been found that the induction may be carried as far as 32,360 lines, or nearly twice as high as is usual in practice. It remains to be seen whether it will be possible to take advantage of these results to obtain a further increase in the output of dynamo-machines. The experiments were carried out with a horse shoe magnet, each core 10in. long and 2in. diameter, and provided with tapering pole-pieces so as far as possible to concentrate the lines into the centre of the field. Small cylinders of iron wound with a single layer of fine wire were placed in the field, the ends of the coil being connected with a ballistic galvanometer, and were then suddenly withdrawn while the deflection of the galvanometer was noted. The residual magnetism was taken account of by means of a second experiment in which the direction of magnetisation was reversed. Three kinds of wrought iron were tested, soft hammered scrap, Swedish iron, and Lowmoor iron. The hammered scrap proved less susceptible than the other two. The absolute values of the deflections of the ballistic galvanometer were obtained by direct comparison with the induction of the terrestrial field. The following table gives the results obtained for Lowmoor and Swedish wrought iron. It will be seen that the curve has become very flat at the higher limit:—

LOWMOOR WROUGHT IRON.		SWEDISH WROUGHT IRON.	
Total Induction.	Current in field-magnets, amperes.	Total Induction.	Current in field-magnets, amperes.
24,700	1·98	27,960	4·08
27,610	4·04	29,730	7·77
28,870	5·81	30,820	10·9
29,350	7·60	31,210	14·2
30,200	11·0	31,630	16·5
30,680	13·5	31,720	18·9
30,830	16·2	32,060	22·9
31,370	21·6	32,360	26·5
31,560	26·8		

The permanent magnetisation was found to have nearly constant value in each case. For Lowmoor iron it amounted to 510 lines per square cm., and for Swedish iron 510 lines,

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INCANDESCENT LAMP MANUFACTURE.—XIII.

BY J. SWINBURNE.

Mounting.

In the early days of incandescent lighting the carbons were clipped to the platinum wire mechanically, but that method is now generally abandoned in favour of mounting by deposition of carbon over the joint. Joints are also made by cementing the carbons into a socket in the platinum wire, and a mechanical grip, with copper deposited over it, is sometimes used. The Swan lamp was for a long time made with a carbon mounted in a socket, and the joint short-circuited over to make good connections. The process is as follows: — The platinum wires are first cut into lengths, and the ends are flattened out by a fly press into little spades. These spades are then drawn through a wire draw plate, so as to curl the flat part round into a tube. The wires are then sealed into glass stems, and these stems are sent to the mounting room. The legs of the carbons are inserted in the tubes and the tubes slightly pinched, so as to hold the carbons more or less securely; the stems are then held by an apparatus which clips the platinum wires quite close to the little tubes or sockets. A smaller short-circuiting clip leans against the legs of the carbon hard enough to make good contact, but not hard enough to run the risk of breaking the carbon. The whole is then immersed in benzol and a current is passed through so as to heat the carbon between the short-circuiting clip and the little tubes of platinum. The benzol is, of course, decomposed by the heat, and carbon is deposited over the joints forming a hard lump, which effectually fastens the carbons to the wires. The carbon must be held vertically with the platinum up and the carbon down, otherwise the deposit does not come over the sockets properly. Benzol is a very good liquid, as it is cheap; but it soon gets black, and it is dirty in use. Mr. Swan has tried aniline, and aniline and benzol mixed. Aniline makes a very neat joint, and deposits very hard grey carbon; but it is expensive, and the use of it is to be avoided as it is poisonous, and the fumes evolved when it is decomposed by heat contain cyanogen. Aniline also attacks the skin, and is apt to give great trouble if it gets into any cut or scratch. Alcohol or methylated spirits is cleaner, but takes a long time to give a thick enough deposit. This method has several disadvantages. The platinum tubes take time to make, and they frequently get broken. If the tubes are broken, and if the wires are sealed into the glass, the waste is considerable. If the carbons are at all fragile, or if the operators are careless, the carbons are often broken off, leaving little bits in the tubes. These can sometimes be picked out with a needle, but the stem is generally wasted. The writer has introduced the process of mounting by short-circuiting without sockets. The platinum wires are mounted in a stem, and the stem is held by two current-conveying clips. The carbon is held so that the ends touch the platinum wires, and a little cement is applied to the joint. The whole is then placed in an atmosphere of coal-gas, enriched with benzol vapour. The circuit is made through the joints, and the current is gradually increased till they are raised to a white heat. When enough carbon has been deposited to make firm and strong joints the process is finished.

The writer's apparatus is shown in Figs. 8 and 9. The cover is removed to show it more clearly. A pair of clamps hold the stem in position by gripping the platinum wires firmly; the platinum wires are bent out to exactly the right shape by a little machine, which will be described under the head of glass blowing. The carbon is mounted on a holder, which consists of a block of hard wood, with clamps at one end. These clamps are made so that they hold the carbon with its legs just the right distance apart. The carbons may have been previously cut to gauge, so that the legs are exactly the same length, or they may have been broken off short at the jaws of the flashing clips. The latter plan is the best; the movable gauge is arranged so that the carbons must be mounted the correct length. When the carbon is placed on the block, and the weights released, so as to exercise gentle pressure, the block is placed on the brass plate, and slid about till the ends of the carbon just touch the platinum wires. A cement or paste of dextrin and plumbago is applied with a camel's hair brush, and left a few minutes to dry. While it is drying the operator prepares another, as each works two short-circuiters. When the cement is partly dried a current is sent through. The circuit enters by one of the platinum clips, and crosses to the carbon, and returns by the other platinum clip. The block for holding the carbon is made detachable, so that the carbon can be placed more easily in it. A brass plate is fastened for it to to rest upon, as the wood is otherwise apt to warp, so that the ends of the carbons do not come opposite the wires. When the carbon is placed a glass cover is put over the apparatus, and the gas is turned on. The gas enters under the joints so as to give them a good supply, and it goes out by a tube at the other side. An ordinary glass shade is used. Mercury should not be used as a seal. A better plan is to stretch a broad rubber band over the edge of the glass so as to make a

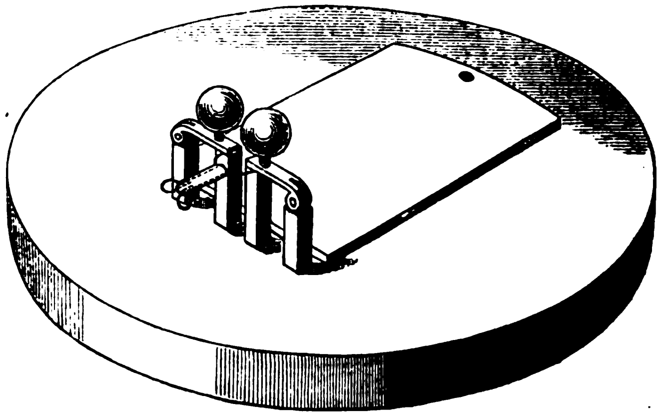

FIG. 8.

sort of inside flange; if the glass is evenly cut this is practically air-tight. Care must be taken that the cement is raised to a white heat, otherwise the joints will be weak, and the carbons will be apt to tumble off the platinums. When the carbons are mounted the stems are placed in trays which hold them the right way up, so that the carbons do not get broken. The trays consist of boards about

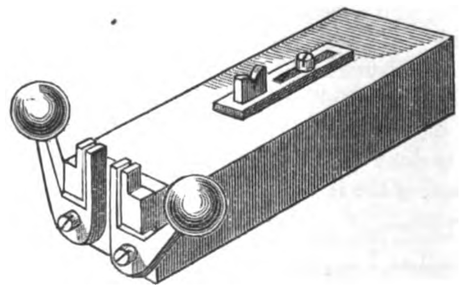

FIG. 9.

10in. square, with 100 quarter-inch holes bored about half way through. It is generally necessary to have several blocks for each apparatus, as the brasswork gets hot. Care must be taken not to let the glare from the white hot joints hurt the eyes of the operator. The glass shades are covered with sheet lead, leaving only the top unprotected. If there is an explosion, the lead prevents the glass from doing harm. A piece of coloured or smoked glass is fixed over the shade, so that the operator can watch the process without injuring his eyes. The electrical part of the apparatus is very simple; it consists of means of regulating the current through the joints. An alternating current machine is very useful. A Siemens machine can be easily arranged to have 4 or 8 circuits, with 5 or 9 terminals. The current through each apparatus is then governed by induction coils, with movable cores. One coil is

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arranged in series with the apparatus, and the other in shunt. The cores of the solenoids are bundles of iron wire, or even rods of iron, though the latter are apt to get hot. The cores are made so as to be slid in or out. At starting, the shunt core is right out, and the series one in, so that the series one practically stops the current, while what little current there is goes by the solenoid in shunt instead of through the legs of the carbons. To increase the current the shunt core is pushed in gradually, and the series pulled out till the whole electromotive force of the machine is on the apparatus and the shunt coil takes almost no current. If the machine is suitable, its self-induction will make the electromotive force fall rapidly as the current increases, which is just what is wanted.

If direct currents are used, as is generally the case, as it is seldom worth while to have an alternating machine for the purpose, the best method is to use secondary batteries. The cells are connected with a switch, which allows the number in circuit to be increased or diminished. An ordinary switch with a solid contact will not do, as, if the contact is made to touch the next section before it leaves the one it is on, one of the cells will be short circuited, while, if it leaves one section before it touches the next, the circuit will be broken for a moment altogether. The moving arm has therefore two contact pieces, with a resistance between them which will stand two volts and a reasonable current for a short time, and these touch neighbouring sections at the same time for a moment. If secondary cells are not available, adjustable resistances are arranged in shunt and in series, just as in the case of the induction coils above mentioned. Water resistances are the best for all work in which exact resistances are not wanted. They are made with lead plates in dilute sulphuric acid. The plates are so arranged that one can be drawn out of the water, or so that the path from one plate to the other through the electrolyte can be made longer or shorter. Of these methods the writer prefers that with the alternating machine and induction coils, or deadeners. He has used Dr. Hopkinson's adjustable closed circuit deadeners, and they act very well, though a cheaper and less efficient form may sometimes be better.

If the platinum wires are not mounted in glass stems, but are supported at the time of sealing, it is more easy to make good contacts to start the short circuit, as the wires can be separately adjusted to the ends of the carbons. The process can thus be carried on under liquid, which is quicker. The ends of the platinum wires may be flattened a little and turned over, so that the ends of the carbon rest against flat surfaces. In mounting carbons for low resistance lamps it is best to work with liquid, and great care must be taken to make the joints of very highly conducting carbon, otherwise they will get very hot when the lamp is run, and the joint may soon go. Though short-circuiting is generally the best method, many makers mount in other ways. Edison, Maxim and Weston use carbons with thickened ends, and clamp the ends. Maxim and Weston use a little bolt and nut and washer. Edison clamps the carbon mechanically, and then deposits copper over the joints by electrolysis. The thickened ends have the objection that they absorb gases, and thus make the lamp more troublesome to exhaust. Carbons made with thickened ends are also more expensive to make, as each carbon has to be made separately, while most carbons are made in thread, a great length being produced at a time.

With short-circuited joints, if a twenty candle-power carbon is broken a little too short it can often be used for a sixteen candle-power lamp of lower volts. Electro-plated joints are bad, because if the lamp is run bright the copper volatilises, and either strikes an arc across from one joint to the other, or at least assists the silent discharge that is always present when the lamp is run bright. In lamps with imperfect vacuums copper from the terminals forms very curious trees of beautifully fine copper filaments. These little trees grow till their fibres intermingle. Some makers fix the ends of the carbons into sockets made by curling the platinum wires into spirals, and cement them in with something plastic, which can be carbonised, such as cement of tar and blacklead. The cement can be carbonised by heating the carbon, with short wires attached, and the carbons cemented into them, and the wires can then be mounted by soldering them to other wires embedded in the glass stem. These cements are always troublesome, however, as they occlude gases and water vapour, and give trouble in exhaustion.

SUBMARINE CABLES.—III.

Writing in a foreign capital, far away from books or papers of reference, we must content ourselves on the present occasion with some general remarks upon Mr. Henniker Heaton's contribution in the *Pall Mall Gazette* of April 2nd, "On Federation by Telegraph." In a controversy of this magnitude, where many millions of pounds are involved, it is absolutely necessary—however unwilling one may be to do so—to look at the personality of the adversary, to demand his credentials, and to inquire why he arrogates to himself the office of arbiter and judge. Mr. Henniker Heaton's contribution is absolutely void of all logical reasoning, and we could easily traverse his specious arguments from beginning to end. But we pause to ask, who is Mr. Henniker Heaton, and what is his position with regard to submarine telegraphy? He is simply a colonial, interested in newspapers, posing in the British Parliament as a Conservative M.P. Australian newspapers have lifted the veil from Mr. Heaton's career, and, so far as we can gather, there is not in that career one single scrap of evidence that either by education, reputation, or commercial aptitude is he qualified to speak as a critic of submarine cable business.

Turning, however, from these uncongenial reflections, let us see what Mr. Heaton actually says. He asserts that the cable companies "have a capital of about 35 millions, a cable mileage of 100,000, a revenue (including subsidies) of £3,173,692, a reserve and a sinking fund of £3,400,000, and their dividends range from 1 to 14¾ per cent." Now these figures partake somewhat of the nature of white lies; they are at once correct and delusive. We are previously told that there are "twenty-six cable companies"; and the figures following would naturally lead his readers to suppose that, at any rate, a fair proportion of these cable companies paid a good dividend. "To 14¾ per cent!" The 14¾ is a handsome dividend; but how many companies pay anything like this? We know of one, and one only—an important company, no doubt—a pioneer company, and as such, we maintain, deserving of 14 or 15 per cent.—especially as its concession is nearly expired. But, after all, the Submarine Company is a mere flea-bite in the cable system, either viewed from the standpoint of capital or mileage. It is exceptionally situated, and ought not to be considered in the argument of Mr. Henniker Heaton. Take this away, and what will his figures amount to? Certainly nothing like 14¾ per cent.

The most glaring part of Mr. Heaton's contribution—and we think one that shows his utter want of business capacity, and his absolute ignorance of the first principles of political economy—is to be found in the socialistic, nay, the extremest communistic, ideas put forward with regard to indemnification. He openly preaches the doctrine of confiscation—and this while professing to be a Conservative M.P. In future the pioneer of a new industry, whether an individual or a company, is not to be reimbursed for the expenditure involved in initiating and developing new industry, because *after* the experience has been gained the work can be done for less money! Does Mr. Heaton mean to tell us that the men who are engaged in perfecting submarine navigation do not expect to be paid for gaining their experience? Are they not to expect a return for the money they are actually expending, because, forsooth, twenty years hence the labour and the money now spent will have enabled them and other people to produce such boats better and cheaper? Does Mr. Heaton mean that the men who have spent £40,000 and five years' labour in perfecting, say, a new battery, are to lose that £40,000 and that five years' labour, or must we emphatically tell him that the money and the labour will have to be

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paid for by the future users of the battery? Why, all our patent laws, all the unwritten laws of civilisation, are diametrically opposed to Mr. Heaton's creed. Enforce this doctrine, and all progress will be stopped. Mr. Heaton says "the cable companies want to be reimbursed the expense of their early and inexperienced efforts when they were groping their way to a solution of the submarine telegraph problem." What is Mr. Heaton's answer to such a proposition as the following:—Aerial navigation is held to be possible and far more comfortable than locomotion by railway or by ship. Suppose he commences to experiment on a system of aerial navigation; spends, or gets others to spend, £35,000,000 upon a successful system connecting the principal business centres of the world—upon what sum would he require a dividend to be paid? Of course when he had spent, say, £20,000,000 before reaching perfection, he would find others, who had learned from his experience, could *then* do for a less sum what he had done—though *they could not extend the system cheaper or better than he could do it.* Would he, we again ask, agree to the confiscation of his extra millions spent upon developing, perfecting, and gaining experience? Are we, in fact, to confiscate a man's or a company's experience? Is experience a valuable commodity or is it not? Can it be bought or sold? We say it has a money value, and to confiscate it is contrary to all ideas of honesty. Our contention in these articles has been "Act upon business principles." Is Mr. Heaton's argument in favour of business principles, or is it addressed to the greedy and unthinking multitude? He suggests that the Government of England, in collusion with the Colonial Governments, should confiscate an experience that has a monetary value calculated at many millions of pounds.

After practically suggesting that confiscation would be preferable to paying for what is coveted, Mr. Heaton goes on to briefly describe the existing system of submarine cables, and points out correctly enough that the system radiates from England. We have shown why this is the case in previous articles, but may say again that the cables were originally designed by business men for business purposes, and only Englishmen had the pluck to find the money, and possessed the brains and energy to develop the system Mr. Heaton wants to ruin, or appropriate without paying for.

Next Mr. Heaton goes in for pessimism. He says:—"With the exception of Canada, all our communications with the rest of the Empire hang literally upon a single thread." No matter how sorry we may feel for Mr. Heaton, we are compelled to be emphatic upon this point, and say they do not. Perhaps in the future we may be enlightened as to where this "one stroke of the knife" is to be given which is to "cut us off from India, from Australia, from the Cape, and from the whole of the British world save Canada," twenty-four hours after a European war begins. We are altogether at sea as regards this vulnerable point, and we cannot believe it to exist.

The secret of Mr. Heaton's antagonism to existing companies is found in the closing paragraphs of this article. He is the advocate of an alternative route—a Pacific line from Canada to New Zealand. He is not so much concerned to show the wonderful point where one cut from a knife would do so much damage, as to get his scheme carried through. It is the *beau ideal* of a cable scheme; it appeals to our patriotism; it will go through our own possessions only; it will cost less than existing cables, and therefore it can afford to carry messages cheaper. We think we have heard a good deal of similar arguments from many an advocate and promoter. By-the-bye, it would be well to ask who are the promoters of this Pacific cable scheme; and if the Conference is to be asked to father the scheme, and the English taxpayer to subsidise it, we might suggest the advisability of looking a little more closely into the "promotion." We will be candid, and tell Mr. Heaton that if the scheme is absolutely necessary for the "maintenance of the integrity of the Empire," and the House of Commons cares to vote the subsidy, the work can be and will be done much more cheaply than he and his colleagues can do it. But we maintain the Pacific cable is not wanted, that it will be a costly undertaking, and commercially it will not pay. The only really good point in the scheme is that the whole undertaking would be from and to British territory. Yet, however, anxious Mr. Heaton may be to keep up our insularity, that question is simply and purely a political and not a commercial question. It is absolutely certain, then, that if the Government think the Pacific cable necessary, they will have it laid at the least possible cost to the taxpayers; but this is not Mr. Heaton's suggestion. This brings us to the statement of Mr. Heaton, "That at present enormous subsidies are paid by the Government to the submarine telegraph companies." We say that this statement is entirely false, and that it is intentionally worded to give the readers of the *Pall Mall Gazette* a wrong impression as to the facts of the case. Let Mr. Heaton give a list of the subsidies paid, and also at the same time let him say if the cables laid with the aid of subsidies could or would have been laid by any sane individual as a purely commercial undertaking. If the hands of a Government are forced by blatant appeal to popular passion to construct cables that cannot pay commercially, then the Government must pay subsidies. These subsidies are paid for "political purposes," and whatever is paid, or has been paid, has saved the nation ten times the amount of the subsidies. That result, however, does not lead us to argue that subsidies should be paid for alternative routes. Anything might happen if the idea as mooted by Mr. Heaton were followed. The world has to put up with the *ifs* and *buts*, and we cannot, therefore, commend subsidies because an *if* comes in. The *if* in one direction is just as likely to happen as the *if* in the other direction, and no doubt, through what the Americans would call the sheer "cussedness" of mundane things, the long Pacific cable advocated by Mr. Heaton would develop a fault just at that inconvenient period when a European war broke out, and the knife was applied to the one vulnerable point in the existing system. If the commercial outlook for this cable is so good, why does not Mr. Heaton, and those who believe in him, lay the cable, and not fuss over it? Mr. Heaton disparages the Eastern and Eastern Extension Companies because they have, "octopus like," fixed their tendrils in every part of the Eastern and Southern world. We should have thought that this action was most commendable, and that these companies have acted in a true business manner, viz., by getting all the business possible, and using the best means in their power to consolidate and to keep it.

ON THE RELATION BETWEEN THE CALORIFIC VALUES OF ELECTRO-CHEMICAL REACTIONS AND THE ELECTROMOTIVE FORCES GENERATED BY THEM.

BY DESMOND G. FITZ-GERALD.

The following sentence, written more than sixteen years ago, may aid the student to obtain a clear idea of the relation between heat-units (calories) and electromotive force (volts):—

"In working a voltaic battery we exchange an equivalent of one electro-positive for an equivalent of another; or, in other words, an equivalent of some electro-positive is necessarily liberated for every equivalent of the positive element that enters into combination. Thus, in the batteries of Wollaston and Smee we exchange an equivalent of zinc dissolved for an equivalent of hydrogen set free; in Daniell's battery an equivalent of zinc for one of copper; in Grove's an equivalent of the same positive element for one of nitric oxide (N O) or of nitric peroxide ($N^2 O^4$); and in that of Marié-Davy an equivalent of zinc for one of mercury. The electro-positive separated from combination is in all cases electro-negative in relation to that which enters into combination. The electromotive force of a voltaic couple is proportionate to the difference between the calorific equivalents of the electro-positive bodies of which one replaces the other in combination within the voltaic cell."*

We may say that, in the case of a free electro-positive and of a radicle forming one component of an electrolyte, the energy with which chemical equivalents tend to combine is

* *The Electric Telegraph Review,* Nov. 12th, 1870. (A Dictionary of Electrical Terms. Art. Circuit-Voltaic).

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THE PERFORMANCES OF VARIOUS DYNAMOS.

Type of Armature.	Machine.	Revolutions per minute.	Velocities.	I.	II.	III.	E. M. F.	Current.	Authority.
Siemens	Edison-Hopkinson	800	2,100	·45	·013	·006	110	300	Kapp and Crompton.
,,	Edison	1,750	2,850	·312	·0065	·00018	125	40	Cornell University.
,,	Weston	1,000	1,850	·234	·0077	·00024	150	20	Prof. Anthony.
,,	Mather	2,750	3,200	·260	·0049	·00010	125	40	Cornell University.
,,	Wenström	460	2,225	·114	·0031	·00025	110	190	*La Lumière Électrique.*
,,	2½ inch	3,000	1,875	·182	·0060	·00006	70	...	Prof. Anthony.
Gramme	Manchester (Mather and Platt)	1,050	3,300	·402	·0075	·00038	110	220	Kapp and Crompton.
,,	Crompton	400	1,620	·230	·0085	·00057	600	120	*Electrician*, London.
,,	,, (Plating)	700	2,840	·336	·0070	·00048	110	490	,, ,,
,,	Crompton	...	...	...	·0095	...	110	217	Crompton.
,,	,,	...	...	...	·0070	...	110	100	,,
,,	,,	...	...	...	·0055	...	60	33	,,
,,	Elwell-Parker	...	...	...	·0080	...	110	460	,,
,,	,, (4 pole)	...	...	...	·0065	...	...	...	Kapp.
,,	,, (2 pole)	...	...	...	·0045	...	...	...	,,
,,	Kapp	...	...	...	·0070	...	110	125	Kapp and Crompton.
,,	Sperry	750	3,150	·226	·0043	·00030	850	23	Cornell University.
,,	Goolden and Trotter	765	2,140	·132	·0038	·00017	56	285	*Electrician*, London.
,,	,, ,,	...	...	...	·0055	...	60	200	Kapp and Crompton.
,,	Old Gramme (1874)	1,000	2,875	·109	·0023	·00011	200	25	Prof. Anthony.
,,	Raffard-Breguet (1886)	1,400	2,750	·117	·0022	·00008	110	35	Crompton.
,,	Ball ("Unipolar")	1,380	3,800	·132	·0016	·00010	470	8	*Electrician and Electrical Engineer*, N.Y.
,,	,, ,,	1,180	...	·113	...	·00010	710	8·2	,,
,,	Deprez (Paris-Creil)	216	1,475	·081	·0033	·00037	3,000	9·9	Levy and Kapp.
Pacinotti	Phœnix	...	...	·290	·0058	·0006	110	380	Kapp and Crompton.
Brush	Brush	850	4,670	·200	0026	·00024	3,000	9·5	Cornell University.
Thomson-Houston		...	...	...	·0019	...	...	...	Kapp.

the measure both of the heat and of the electromotive force which the combination is capable of generating.

The unit of heat or *calorie* of Dulong is the heat required to raise a gram of pure water through 1° cent., at a temperature intermediate between 0° and 4°. (The calorie ordinarily adopted by engineers on the Continent is a thousand times greater than that of Dulong).

The numerical relation between calories and volts is readily arrived at, with a degree of accuracy which is dependent upon that of the mechanical equivalent of heat and that of the electro-chemical equivalent of copper or of silver.

The equation, in absolute C.-G.-S. electro-magnetic units, for the work done by a current, C, under the electromotive force E, in θ seconds, is simply

$$W = C\,E\,\theta \textit{ ergs.}$$

But if, in lieu of the absolute unit of current, we take the B.A. unit or *ampere* (10^{-1} absolute C.-G.-S. units), and, in lieu of the absolute unit of electromotive force, we take the B.A. unit or *volt* (10^8 abs. C.-G.-S. units), the equation becomes—

$$W = C\,E\,\theta \times 10^7 \textit{ ergs.}$$

And if, in lieu of the absolute C.-G.-S. unit of work, the *erg*, we take the *calorie* or gram-centigrade unit of heat, the value of which is $4{\cdot}2 \times 10^7$ *ergs*, the equation then becomes—

$$H = \frac{C\,E\,\theta}{4{\cdot}2} \textit{ calories.}$$

The calorific effect of the *ampere* current under unit electromotive force during unit time is, therefore, ·238 calorie.

From the last equation we may derive one for E, showing that this value varies as the heat effect when quantity of electricity is constant.

$$E = \frac{H \times 4{\cdot}2}{C\,\theta} \textit{ volts.}$$

Now, there is one particular value of $C\,\theta$ which corresponds to the electro-chemical reaction involving the gram equivalent, and which is therefore termed the *equivalent of electricity*. Taking the electro-chemical equivalent of silver as ·001118 gram per ampere-second (coulomb), or 4·025 gram per ampere-hour, the equivalent of electricity is 96,600 coulombs, or 26·7 ampere-hours. When this constant value for $C\,\theta$ is adopted the equation for volts becomes

$$E = \frac{H \times 4{\cdot}2}{96600} = \frac{H}{23000} \textit{ volts.}$$

This equation signifies that the E.M.F. of any constant voltaic couple is the ratio to the number 23,000 of the number of calories evolved in the circuit by the passage of a quantity of electricity, generated by the couple, represented by 26·7 ampere-hours; or, what is the same thing, by the combination of the gram-equivalent of an electro-positive, such as zinc or lead, forming one of the elements of the couple.

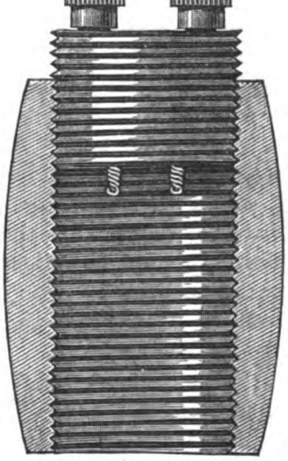
NOTES ON THE PERFORMANCE OF SOME DYNAMOS.

The interesting table which we print above has been contributed by Mr. D. C. Jackson, of the Cornell University, to the columns of the New York *Electrician and Electrical Engineer*. It is only necessary to add that the column headed velocities gives the peripheral speed in feet per minute, and the columns marked I., II., III., have the following significations:—

I. Volts generated per foot of armature wire.
II. Volts per foot of wire and per unit peripheral velocity.
III. Volts per foot of wire and per one revolution per minute.

THE MAC-CARTHY LAMP HOLDER.

We have received from Mr. MacCarthy, of Dundalk, a specimen of a lamp holder which he has made use of for some time past, and which is represented in the adjoining figure. The holder was designed in order to obviate the tendency of the lamps to swing from the platinum loops, and has proved effectual in greatly reducing the number of lamps rendered *hors de combat* from the loops giving way. This feature is also of special value for flour mill installations, where the spark which is sometimes formed at the loop as the lamp vibrates to the jarring of the machinery adds, to a certain extent, to the fire-risk. There are, of course, other methods of connection in use which effect the same purpose, but Mr. MacCarthy's device is unquestionably neat and simple. It will be seen from the figure that it consists of a wooden cylinder, which has a thread cut all along its inner surface. The disc or boss through which the terminal wires are passed can thus be screwed into the cylinder until the bulb of the lamp comes home against its end, and the platinum loops are thus completely enclosed and protected.



MacCarthy Holder (full size).

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 491
Incandescent Lamp Manufacture.—XIII. By J. Swinburne. Illustrated ... 496
Submarine Cables.—III ... 497
Relation between Calorific Values of Electro-Chemical Reactions and the E.M.F.'s Generated by them. By Desmond G. FitzGerald ... 498
Notes on the Performance of some Dynamos ... 499
The MacCarthy Lamp Holder.. 499
THE PADDINGTON INSTALLATION ... 500
Correspondence. Illustrated... 501
Induction Coils Graphically Treated. By Gisbert Kapp.. 502
Applications of Electricity to Mining Operations. By F. J. Rowan, C.E. (Concluded.) 504
The Stafford and Eaves Electro-Plating Dynamo. Illustrated 506
The Resistance of Faults in Submarine Cables. By A. E. Kennelly, M.S.T.E. (Continued.) Illustrated. ... 506
The Migration of Ions and an Experimental Determination of Absolute Ionic Velocity. By Dr. Oliver Lodge ... 508
Automatic Electric Gas Lighters. Illustrated ... 509
The Electric Light at the Royal Exhibition, Newcastle-upon-Tyne ... 510
Electricity at Hatfield ... 511
Companies' Meetings—
Western Counties and South Wales Telephone Company 512
City Notes, &c. ... 512
Companies' Share List ... 512

THE PADDINGTON INSTALLATION.

Dealing in these columns recently with the various phases of opposition to which the electric light has been subjected both at home and abroad, our description would be incomplete without some mention of the legal proceedings which for six or eight months past have been threatening with extinction the important installation at Paddington Railway Station. Only a few weeks ago we commented with some severity on the extraordinary and, as it seemed to us, arbitrary regulations promulgated by the Paris Municipality in respect to installations in that city; but after reading the case of Cocks and others *versus* the Great Western Railway Company we begin to understand the meaning of some of those regulations, and to realise that they represent current popular prejudices, and are not dictated solely by excessive anxiety for the public safety. If the plaintiffs in the case just referred to had framed the Paris regulations they would apparently have been more stringent than they really are, for the trustees and inhabitants of the Paddington estate are evidently disinclined to any compromise whatever, treating as an unbearable nuisance things which would be tolerated without a murmur if they were not innovations with which Paddington has no sympathy.

We are justified in this suspicion by the remarks of the judge who has had the case before him from the first. He has heard all the evidence on both sides, and in the earlier stages seemed disposed to uphold the objections of the plaintiffs, and to enforce impossible conditions on the defendant company. But he has ended by visiting the aggrieved inhabitants in their own dwellings, and has come back to court with the declaration that their complaints have been much exaggerated. We heartily approve of the judge's action in this matter. When a question of nuisance arises personal inspection on the part of the Court itself is often the only way to decide between the conflicting testimony of experts. Not very long ago an eminent judge settled a prolonged dispute about a noxious factory of some kind, the smell of which was truly abominable, but the plaintiff could not give it a name. The defendants described it as merely ammoniacal. His lordship, after brief inspection, declared it to be simply demoniacal, and gave instant judgment for the complainants. Mr. Justice NORTH, in a similar spirit, visited the works of the electric lighting installation at Paddington and some of the houses which were alleged to be greatly affected by the vibration, smoke, and steam of the engines; and he came to the conclusion that the plaintiffs' witnesses had exaggerated the nuisance, there being no appreciable discomfort or annoyance occasioned by the works. The writ for sequestration was therefore refused; and unless the case is carried to a higher court the company may now continue their work with the assurance that they have done all that law and justice can require them to do.

This action has more than a local interest for our readers. It may be taken as a test case by which any future proceedings of the kind will be ruled. It is also instructive in respect to the actual measures adopted by the Great Western Company to remove every reasonable cause of complaint. If the Electric Light is to become popular, the necessary engines and machinery must often be lodged in places similarly situated to those adjoining the Paddington Station, and may sometimes, therefore, arouse similar prejudices among the surrounding inhabitants. Had this case gone against the company after the quite exceptional precautions they have taken to deaden sounds and suppress the nuisance of smoke and steam, nobody could hope to complete an installation in a "respectable" neighbourhood without provoking an injunction for nuisance. On the other hand, it has been made plain that in thickly inhabited districts, and what are styled first-class neighbourhoods, it will be necessary to adopt precautions similar to those which have satisfied the judge in the Paddington case, and nothing short of these will pass unchallenged. Since July last, when the injunction was applied for, the Great Western Railway have expended a great deal of money in experiments and alterations in order to satisfy the plaintiffs. This is a fact that has to be faced by electric lighting engineers; and on the whole it is fair and reasonable. The special hardship in this particular case would have been the summary stoppage of the works if the judge had not suspended the injunction in order to give the defendants time to effect their improvements. The plaintiffs on one occasion, last October, even appealed against a further extension of time; and though they were unsuccessful, they renewed their attack in the same spirit directly the period of grace had expired, although in the meanwhile every cause of annoyance had been successfully removed.

We have a right to complain of the spirit in which these proceedings have been pressed on; but their satisfactory termination will probably prevent a repetition of them elsewhere, provided due care is taken to keep within the limits marked out by this case. This, we say, is a reasonable proviso; because it should be remembered that the annoyance, trifling as it may be, is brought to the inhabitants, the inhabitants do not go to the annoyance. In law the distinction is important. Not many years ago an unmitigated nuisance of the oil-boiling persuasion at one of our seaport towns was, after many legal fights, ruled to be lawful, because the suburbs had expanded

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to the stench, whereas for a great number of years the stench had been far away beyond the reach of the suburbs. The doughty oil-boiler maintained his rights, and the town corporation had to buy him out at a fair price, which under the circumstances they ought to have done long before. The works of an electric light installation can never be such a nuisance as that; but in æsthetic localities nerves and noses are made to match, and we cannot offend them with impunity. Gasworks have the advantage in this, that they can be erected far away from the area of consumption. Had it been otherwise gas would have been heavily handicapped by a fiercer opposition than it has ever had to encounter. For electric lighting the works must be somewhere near the centre of operations; and hence the necessity for avoiding all those causes of annoyance which Paddington people regard as a nuisance. That this can be done effectually is proved by the result of the proceedings against the Great Western Railway Company.

CORRESPONDENCE.

THEORY OF SECONDARY CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to Mr. J. Swinburne, I beg to say that there is no error, due to the old notation or otherwise, in my statement (p. 457) that "By the combustion in oxygen of the gram equivalent of Zn, Andrews obtained 42,282 and Dulong 42,185 calories." The datum is taken from the table headed "Heat Developed during Combustion in Oxygen," which will be found in Miller's "Chemical Physics," and elsewhere.

The value, 46,245 calories, for the gram equivalent of Pb combining with SO_4, corresponds to an E.M.F. of 2 volts—not of one volt as stated by Mr. Swinburne. The value 156,110 calories is absurd.—Yours, &c.

DESMOND G. FITZGERALD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As an outsider and a looker-on in the discussion which has arisen out of Mr. FitzGerald's paper, I ask the privilege of making one or two comments on the letter from Mr. Swinburne in your issue of the 8th.

There are a certain number of electricians who deal with battery matters without concerning themselves about the principles of chemistry, a science with which they possess only an external acquaintance. From such as these I expect all manner of doctrines and views. But Mr. Swinburne is emphatically a chemist, and one in whom I hope to find a supporter of the old dynasty of the house of Faraday; and it is a pity that we should have from him any inverted agencies of "contact" forces, or anything of the kind, in order to account for the E.M.F. of voltaic arrangements, whether primary or electro-formed.

There are few effects in nature which can be referred to one cause alone; even when a piece of iron falls to the ground it would be rash to say that its fall was entirely due to gravity, for some fractional percentage of the agency at work is probably of a magnetic character. And similarly the action of the voltaic cell is doubtless one in which certain minor causes participate in a trifling degree. But, on the whole, the true state of things is best conveyed by declaring that the cause which urges the voltaic current is nothing else than *chemical force*. The E.M.F. of a cell actually is the chemical force at work in it. Turning now to Mr. Swinburne's objections, which lead him to take a contrary view, it is only necessary to remember that there may be chemical force acting, though no chemical change takes place, viz., in the case of chemical force which is balanced or perhaps overpowered, by opposite force. And if a greater E.M.F. is necessary to electrolyse water when the current passes from a peroxide anode to zinc cathode than with platinum electrodes, the reason is simply that in the former case there is an opposing chemical stress at work between the second O of the PbO_2 and the H of the water, and again between the Zn and the O of the water, while the corresponding actions at the platinum electrodes are of a less powerful character. Passing to the second objection, there is no anomaly in a single-liquid cell giving two volts, for we must count not the liquids but the actions. In a cell with electro-formed lead plates in dilute acid the liquid is, to use a general term, oxidising the spongy lead, and the peroxide plate is oxidising the liquid.

As regards Mr. Swinburne's Dr. and Cr. reckonings, I am a good deal perplexed as to the principles upon which he makes the entries. Sulphate of lead being formed on both plates, he is certainly wrong in putting both these items on the credit side; proceeding thus he can never hope to square off the volts in his balance-sheet.—Yours, &c.,

37, Burlington-road, W. E. ALDRED WILLIAMS.

THE USE OF CELLULOID IN SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I can assure Mr. Arthur Shippey that I had no knowledge of the fact of his firm having exhibited in 1883 samples of the Woodward spongy lead plates, divided by celluloid combs. I do not even know what a Woodward spongy lead plate is, although no doubt I ought to know. Possibly Mr. T. J. Jones knows all about it, but, as I did not consult him when I ascribed to him the credit of having introduced the new material, any mistake that may have been made is mine, not his. I am sorry if I have inadvertently ignored any claim in this direction of Messrs. Shippey Brothers.—Yours, &c.,

DESMOND G. FITZGERALD.

TAUSSIG'S AUTOMATIC FIRE AND BURGLAR ALARM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit me to trouble you with a few further remarks with respect to the claim of Dr. Taussig to my system of automatic fire and burglar alarm, because it is not a combined automatic and manual one.

I must refer him to previous and subsequent patents where the automatic and manual instruments are fully described. Had the telephone been in existence at the date mentioned we should doubtless have included its use in the combination. In all our earlier pamphlets on the subject, a Morse key is shown beneath the apparatus for signalling, to be used as described by Dr. Taussig, and the apparatus, both automatic and manual, occupying 30ft. of frontage at the Crystal Palace Exhibition, worked upon one wire.

The claim of novelty in the combination is the more absurd as the burglar alarm itself is a manual apparatus operated involuntarily.

The perfectly original idea that a combination containing cam wheels, &c., is not patentable, because these mechanical contrivances have been previously in use in other systems, is scarcely likely to assist Mr. Maier, as their employment in Dr. Taussig's case will scarcely make of it a marketable patent.

If Mr. Maier will read over the specification No. 640, of 1874 (Davies and Higgins), "Improvements in Signalling by Electricity," he will find the combined automatic and manual signalling fully described.

The enclosed extract from the patent above mentioned is to the point.—Yours, &c., F. HIGGINS.

Cornhill, E.C., April 7th, 1887.

Extract

"In combination with the call instrument is used an automatic fire alarm, so arranged that upon the temperature of the room, floor, or vault in which the apparatus is placed being raised beyond a predetermined point a thermostat liberates its mechanism by the expansion of a metal, either

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directly by the bursting of a glass ball and stem filled with mercury, or by means of the shifting of a contact maker and diversion of the current of electricity (which is constantly flowing through the instruments) from its direct path to another through an electro-magnet, whose armature retains the trigger of the call or instrument in position ready for sending a signal. By this means a large warehouse or factory can be connected by a single wire with the police office and fire-engine house miles distant, and with any number of intermediate alarms, or with every pile of goods and every floor up to about 200 for a signal wire. Each signal would indicate the position of the fire."

AUTOMATIC ACCUMULATOR SWITCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps the following description of an automatic accumulator switch, which I designed and made for our installation of electric light, would be of interest to some of your readers.

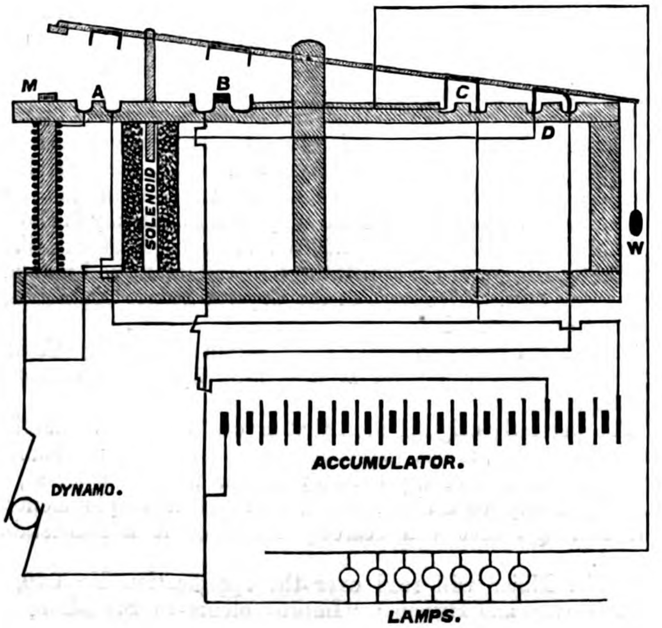
I think there are some new points about it. Our dynamo is situated about 600 yards from the house. It is driven by an Alcott turbine of 10 horse-power. The leads are carried on poles within 100 yards of the house, and then by cables underground to the accumulator room. There is a slight leakage from the cables, so in order to avoid this the switch is placed close to the accumulators. It is perfectly automatic.

1st. It goes into action when the dynamo starts, and when the E.M.F. exceeds that of the battery.

2nd. It breaks contact before the E.M.F. falls below that of battery.

3rd. It cuts out three or more cells from the lamp circuit while the dynamo is running, and restores them when it stops, and thus keeps the lamps practically the same during charge and discharge.

4th. There is no waste of current through any shunt coils.



The sketch shows position of switch when dynamo is not running. When dynamo starts the solenoid draws down the rocking lever. This action puts the magnet M and accumulator into circuit through mercury cup A, at the same time cutting out the solenoid. When cups C are connected, the whole 30 cells are on the lamps; when cups B, only 27 cells. The weight W is adjusted so that the solenoid will not pull the lever down until the E.M.F. is above that of the battery.

The gates of the turbine are automatically shut, and the wheel thus stopped by a cord and weight attached to the lever and rack of the gates. A trigger is held up by a small electro-magnet in the main circuit. Turning off the main switch at the house allows this weight to act and stop the turbine.—Yours, &c., W. E. WILSON.

Daramona, Streete, Rathowen, Ireland,
April 10th, 1887.

KENT'S AUTOMATIC ACCUMULATOR SWITCH

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the description of my accumulator switch, which you were good enough to notice in last week's *Electrician*, one of the chief points has apparently been overlooked, and that is that it automatically closes the circuit at any desired difference of potential, as well as breaking it in case of a reversal. There is also an obvious confusion in the lettering of the coils, B being, of course, a coil of low resistance, and not high resistance. The switch is designed to be so thoroughly automatic that it may be locked up and never touched.—Yours, &c.,

J. M. V. MONEY-KENT.

Connaught Mansions, Victoria-street, S.W.,
April 14th, 1887.

BRAY ELECTRIC TRAMWAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last two issues I have read with interest your notes on the above subject, and I may perhaps be permitted, having some knowledge of the proceedings, to correct a few errors into which you have inadvertently fallen. In the first place, parliamentary powers have not been obtained for this line, as they are unnecessary, a provisional order of the Privy Council being sufficient under the Tramways (Ireland) Act. In the second, township commissioners in this country do not construct tramways themselves. In the third, far from sanctioning the use of horses, the commissioners inserted in their resolution approving of the scheme a clause *binding* the promoters to work the line by electricity within two years. It is quite possible that the line may be opened as an electric tramway, but the promoters have reasons (which may be referred to on a future occasion) for taking powers to start the line with horses. The fear of giving alarm to the spirited animals driven by local carmen did not, I think, weigh very heavily with the promoters.—Yours, &c., A. E. P.

Dublin, April 4, 1887.

INDUCTION COILS GRAPHICALLY TREATED.*

BY GISBERT KAPP

An impression is prevalent amongst practical electricians that the investigation of alternating currents, of their production by dynamo machines, and of their utilisation in transformers or induction coils, is a matter of extreme difficulty, requiring complicated mathematical formulæ, if we wish to reduce the working conditions of a given set of apparatus, and the results obtainable with it, to actual figures. We find in text books, and in articles which have appeared in scientific publications, elaborate mathematical expressions which are well calculated to justify the impression above alluded to, not only on account of their inherent complexity, but also because, being evolved on strictly scientific principles, and from laboratory experiments, the connecting links with actual practice on a large scale are often left obscure or entirely neglected. As a general rule, practical electricians have neither sufficient knowledge of higher mathematics, nor the necessary leisure to establish these connecting links for themselves; in other words, to fish out from a mass of theory that which is of real practical importance, and to apply it to the actual design of apparatus; these long and elaborate mathematical investigations are, therefore, of very little use to them. If it were possible to emancipate ourselves from theory altogether, and investigate the subject simply by experiments carried out on a large scale in the work-

* From *Industries*, April 8th, 1887.

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shop, the results obtained would, no doubt, be more readily applicable to practical work than abstruse formula; but, on the other hand, it would not be safe to generalise from such results. Experimental investigation of many mechanical problems, such as the lever, the screw, blocks and falls, &c., would by itself entirely suffice to obtain by generalisation a good working theory of these appliances; but, in other cases, where the time element is of influeuce, our senses are insufficient to grasp the whole of the phenomena involved in the experiment, and, under these conditions, the attempt to generalise from experiments only must lead to erroneous results. Take, as an example, the case of an alternate current dynamo, working on a circuit which has considerable self-induction. A person having no theoretical acquaintance with the behaviour of alternating currents, would compute the rate of doing work in the circuit by simply measuring the current (say with a Siemens dynamometer), and the terminal pressure of the machine (say with a Cardew voltmeter), and multiply the two. The product he would, generalising from his experience with continuous current machines, consider equal to the rate of doing work. But this would be completely wrong, because he would have neglected the time element, which cannot be grasped by his senses. It can, however, be very easily brought within the domain of calculation and measurement; but in order to do so we must perform a theoretical investigation. Our theory, to be of easy application, should not only be as simple as possible in itself, but, what is even more important, it should take as a starting point some conception already familiar to the practical electrician, and it should give the final result in a shape and in terms also familiar to him.

In the following, the conceptions of magnetic lines of force and magnetic resistance, both of which in the case of the continuous current dynamo have been generally accepted as the basis of its theory, are taken as the starting point. The textbook method of investigating alternating currents is to begin with the assumption of a certain impressed E.M.F., then to introduce certain coefficients of self and mutual induction, and to establish for the resultant currents certain differential equations which, in some special cases, are capable of a fairly easy solution. If desired, the resultant magnetisation of the core can be found as a last operation. In the present investigation we shall reverse this order. We assume a certain magnetisation of the core, and proceed backwards, so as to obtain the impressed E.M.F. as a final result by a graphic method. After the graphic method has thus been fixed, it will serve also in those cases where the impressed E.M.F. is given and the other quantities are required to be determined. Before entering on the investigation, it is, however, necessary to make an assumption regarding the function according to which the impressed E.M.F. varies with time. It is customary to assume that the E.M.F. is a harmonic function, such, for instance, as would obtain in a coil revolving round an axis in its own plane with uniform angular speed in a uniform magnetic field. If A be the area of the coil, m the induction (number of lines per square centimetre of field) and ω the angular velocity; and if we count the time t from the moment that the plane of the coil is vertical to the lines of the field, we find the number of lines threading through the coil at an angular position $\alpha = \omega\, t$.

$$Z = m A \cos \alpha$$

The E.M.F. at that instant equals the rate of cutting lines at that instant, viz.,

$$e = -\frac{dZ}{dt},$$

and if we call T the time required for one revolution, and note that $\omega = \frac{2\pi}{T}$ we find the impressed E.M.F. in absolute units,

$$e = \frac{2\pi}{T} m A \sin \alpha$$

This will be a maximum when $\alpha = 90°$—that is, when the plain of the coil is parallel to the lines of force. Let E be this maximum, then

$$e = E \sin \alpha$$

where $\sin \alpha = 2\pi \frac{t}{T}$ and $E = \frac{2\pi}{T}$ times the greatest number of lines which can pass through the coil. To obtain e in volts, we must express E in volts, viz.,

$$E = \frac{2\pi}{T} Z \times 10^{-8}$$

where $Z = m A$, the full number of working lines.

A familiar mechanical illustration of a harmonic motion is the apparently oscillatory motion of a crank pin, as seen end on. Suppose we look down on the crank of a well pump, then (neglecting the influence of the finite length of connecting rod) the position of the pin on the right or left of the centre line is a proportional measure for the speed of the piston at any instant. In other words, the horizontal projection of the crank radius will graphically represent the speed of the piston if the scale of the diagram is so chosen that the length of radius represents maximum speed. This method of representing varying quantities by the projection of lines revolving round a centre is the basis of our graphic theory of transformers. It must be pointed out that the method can only give correct results if the quantities vary according to a true harmonic law, and the question naturally arises whether this is the case with the impressed E.M.F. in dynamo machines as actually constructed. As a general rule, it may be safely assumed that this will not be strictly the case. The impressed E.M.F., especially in machines containing iron in the armature, will vary according to a much more complicated law, and, perhaps, one which cannot even be expressed as a continuous mathematical function; but the deviation from a true sine function has, in the few cases which have been experimentally investigated by Dr. Hopkinson and others, been found to be comparatively slight, and hence we shall not commit a very great error if we assume the sine function to hold good in practice. Another and in itself sufficient reason for this assumption is that the greater accuracy which might, perhaps, be obtained by taking a different function as basis of the investigation would be accompanied by such complications as to render its easy and practical application impossible. Where the difference between the actual and the assumed function is great a correction might be applied in the shape of a coefficient which could be found by experiment. In the following it is therefore assumed that the E.M.F., acting upon the terminals of either a single coil having self-induction, or upon those of the primary of a pair of coils having self and mutual induction, is a simple harmonic function of the form

$$e = E \sin 2\pi \frac{t}{T},$$

where E is the maximum E.M.F. occurring at the times $t = \frac{1}{4}T$, $t = \frac{3}{4}T$, &c.; and T is the time of a complete phase, consisting of two reversals. It is further assumed that the coils contain an iron core, forming part of a completely closed magnetic circuit, so that the electric and magnetic circuits are relatively to each other in a position which might be familiarly described as that of two neighbouring links in a chain; and that no leakage of lines of force takes place outside the core. The latter assumption is of special importance, because it is only under this condition that the same number of lines of force are cut at each reversal by every turn of the coils, and that the induced E.M.F. of each coil may be considered proportional to the total induction and the respective number of turns.

As regards the first assumption—viz., that of the threading of one circuit through the other, it may be as well to point out in this place that the exact manner in which the circuits are arranged is, on purely theoretical grounds, of no importance, so long as in different arrangements the total magnetic flow through the core, and the total current turns through the coils, are the same. From a practical and commercial point of view, however, that arrangement will evidently be the best in which both the path of the lines and the length of wire in the coils are reduced to a minimum. Thus a ring-shaped inductor wound in the Gramme fashion—that is, with the iron inside and the copper outside—will not be as economical in weight of materials used as the inverse arrangement of copper coils inside, and iron wire wound over them to form the outside. In the following we shall, however, not limit the investigation to any one special arrangement, but simply assume that the conditions mentioned above are fulfilled. It

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is evident that the phases of induced E.M.F.'s and currents must all be equal to, though not coincident with, that of the impressed E.M.F., and each of these quantities can be represented by a similar function to that given above, viz., as the product of a maximum value, and the sine of an angle.

1. *Single Coil.*—If the greatest induction in the core remains within the limit for which direct proportionality between exciting power and total induction can be assumed, the induced E.M.F. remains proportional to the current. Let $i = \text{I} \sin \alpha$ and $z = \text{Z} \sin \alpha$ represent respectively the current and total induction (total flow of lines), I and Z being maximum values, and $\alpha = \frac{2\pi t}{\text{T}}$. In establishing these equations, it is assumed that the actual magnetisation is, in phase, coincident with the magnetising current (exciting power), and that there is no difference between an ascending and descending magnetisation. The first assumption is probably correct, whilst the latter is not; but, by sub-division of the iron core, the error can be somewhat reduced. It should also be noted that another error, due to saturation, tends to compensate for the neglecting of hysteresis, and, for the sake of simplicity, both these errors are assumed to be unimportant, and are neglected. If the coil consist of τ turns of total resistance r, the induced E.M.F. at any moment is $\tau \frac{dz}{dt}$, and the E.M.F. required to overcome the resistance is $r\,i$. Writing $e\iota$ and $e\rho$ for these quantities, and $\text{E}\iota$ and $\text{E}\rho$ for their maxima, we find the impressed E.M.F. e by adding $e\iota$ and $e\rho$.

$$e = \text{E}\iota \cos \alpha + \text{E}\rho \sin \alpha;$$

and since this must evidently be a sine function, we can write $e = \text{E} \sin (\alpha + \phi)$; where ϕ is a certain angle smaller than $\frac{\pi}{2}$.

The value of ϕ is found from the consideration that for $\alpha = 0$, $e = \text{E} \sin \phi$; and for $\alpha = \frac{\pi}{2}$, $e = \text{E} \cos \phi$;

$$\tan \phi = \frac{\text{E}\iota}{\text{E}\rho};$$

$$\text{E}\iota = \frac{2\pi}{\text{T}} \tau \text{Z}; \ \text{E}\rho = r\text{I}; \ \text{Z} = f(\text{I}).$$

For low degrees of magnetisation, the function of I, which gives the total induction Z, takes the form of a constant factor depending on the quality of the iron, and the configuration of the core. It can, with sufficient accuracy for practical purposes, be represented by

$$\mu \frac{4\pi\tau\text{I}}{\frac{l}{a}},$$

where μ is a coefficient varying with the quality of the iron, l is the mean length of the path of the lines, and a the cross section of the core, which we assume to be uniform. Writing R for $\frac{l}{a}$, and K for $\mu 4\pi$, we have

$$\text{Z} = \text{K}\frac{\tau\text{I}}{\text{R}}.$$

In this expression, R represents the magnetic resistance, and the influence of higher degrees of magnetisation can be taken into account by multiplying $\frac{l}{a}$ with a factor depending on the degree of magnetisation. This factor can either be obtained from curves of magnetisation such as given by Dr. Hopkinson in his paper on the "Magnetisation of Iron,"* or by the adoption of an empirical formula. From experiments on dynamo machines, I have found the factor $\tan\left(\frac{\pi\sigma}{2}\right) : \frac{\pi\sigma}{2}$ (where σ is the ratio of actual induction to the possible maximum induction) to give fairly satisfactory results.

(*To be continued.*)

* Philosophical *Trans.* Royal Society, 1886.

APPLICATIONS OF ELECTRICITY TO MINING OPERATIONS.

BY F. J. ROWAN, C.E.

(Concluded from page 484.)

IV.—*Transmission by Cables.*

This is the simplest system, but is more easy to work at short distances. Supporting pulleys are used every 100 metres where the distance is great; or intermediate stations are established, in order to reduce the repairs, which are heavy when a single cable is used to transmit power to a great distance. The losses of work on this system are due to friction, resistance of the air, slipping of the cable on the pulleys, and the rigidity of the cable. These losses are found to amount to 4 per cent. per 100 metres, which gives a useful effect, $\text{E}_u = 0{\cdot}96$ per 100 metres. This agrees with Hirn's results, who found that, in transmitting 100 H.-P. to 150 metres, a loss of 4 H.-P. only took place. The losses become less for intermediate stations, so that 90 per cent. can be obtained for 1 kilometre. Experience also shows that, for lines of 1 kilometre and upwards, divided in stations of 100[26] metres apart, the loss is 1 per cent. per 100 metres. An installation near Frankfort exists for transmitting 100 H.-P. to 1,000 metres in 8 divisions of 125 metres, and not more than 8 H.-P. are lost, this making the useful effect—

$$\text{E}_u = \frac{100 - 8}{100} = 0{\cdot}92.$$

Similarly to the other cases, we obtain for distances of—

Metres	100	500	1,000	5,000	10,000	20,000
E_u =	0·96	0·93	0·90	0·60	0·36	0·13

The following tables give the results founded on these figures of calculations of cost in francs per effective H.-P. per hour of different amounts of power transmitted to various distances:—

26. 100 metres = 328 feet or 109 yards.
1,000 „ = 3,280 „ 1,093 „
125 „ = 410 „ 136 „

TABLE I.—*Electrical Transmission.*

Effective H.-P. Hours transmitted.	Distance of Transmission.						Kind of Prime Motor.
	100 Metres.	500 Metres.	1,000 Metres.	5,000 Metres.	10,000 Metres.	20,000 Metres.	
	Fr.	Fr.	Fr.	Fr.	Fr.	Fr.	
5	0·235	0·242	0·251	0·300	0·342	0·541	Steam Engine.
10	0·209	0·216	0·221	0·264	0·322	0·504	
50	0·195	0·201	0·207	0·237	0·284	0·441	
100	0·186	0·190	0·199	0·227	0·274	0·425	
5	0·036	0·037	0·039	0·046	0·054	0·087	Hydraulic Engine.
10	0·027	0·029	0·030	0·037	0·049	0·074	
50	0·024	0·025	0·027	0·030	0·032	0·057	
100	0·021	0·022	0·024	0·027	0·029	0·047	

TABLE II.—*Hydraulic Transmission.*

Effective H.-P. Hours transmitted.	Distance of Transmission.						Kind of Prime Motor.
	100 Metres.	500 Metres.	1,000 Metres.	5,000 Metres.	10,000 Metres.	20,000 Metres.	
	Fr.	Fr.	Fr.	Fr.	Fr.	Fr.	
5	0·261	0·295	0·329	0·680	1·091	2·066	Steam Engine.
10	0·247	0·266	0·290	0·529	0·801	1·495	
50	0·170	0·177	0·187	0·302	0·479	0·814	
100	0·169	0·176	0·185	0·299	0·431	0·712	
5	0·030	0·040	0·050	0·144	0·260	0·499	Hydraulic Engine,
10	0·026	0·031	0·039	0·099	0·172	0·330	
50	0·016	0·019	0·022	0·047	0·079	0·149	
100	0·016	0·018	0·020	0·045	0·075	0·119	

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TABLE III.—*Compressed Air Transmissions.*

Effective H.-P. Hours transmitted.	Distance of Transmission.						Kind of Prime Motor.
	100 Metres.	500 Metres.	1,000 Metres.	5,000 Metres.	10,000 Metres.	20,000 Metres.	
	Fr.	Fr.	Fr.	Fr.	Fr.	Fr.	
5	0·281	0·308	0·343	0·603	0·992	1·745	Steam Engine.
10	0·265	0·280	0·298	0·466	0·651	1·079	
50	0·210	0·220	0·227	0·299	0·363	0·551	
100	0·209	0·212	0·217	0·272	0·322	0·469	
5	0·041	0·049	0·060	0·132	0·250	0·464	Hydraulic Engine.
10	0·036	0·040	0·046	0·091	0·148	0·413	
50	0·022	0·026	0·029	0·046	0·067	0·112	
100	0·022	0·024	0·025	0·037	0·052	0·086	

TABLE IV.—*Transmission by Cables.*

Effective H.-P. Hours transmitted.	Distance of Transmission.						Kind of Prime Motor.
	100 Metres.	500 Metres.	1,000 Metres.	5,000 Metres.	10,000 Metres.	20,000 Metres.	
	Fr.	Fr.	Fr.	Fr.	Fr.	Fr.	
5	0·117	0·152	0·196	0·569	1·085	2·374	Steam Engine.
10	0·116	0·144	0·177	0·469	0·886	1·991	
50	0·112	0·122	0·135	0·265	0·470	1·156	
100	0·024	0·119	0·127	0·230	0·399	1·016	
5	0·011	0·020	0·031	0·130	0·259	0·507	Hydraulic Engine.
10	0·010	0·017	0·026	0·100	0·199	0·416	
50	0·010	0·011	0·012	0·040	0·075	0·167	
100	0·009	0·010	0·011	0·029	0·052	0·124	

The result of these comparisons is that assuming no special reasons for the adoption of any one of the systems in a given locality, electricity and cables are the best agents for distributing power. Of these two, cables give the cheapest transport up to one kilometre, and electricity beyond that distance.

It appears that hydraulic power transmitted by electricity to a distance of 20 kilometres costs less than the same power produced on the spot by a large steam engine, so that the power obtained from waterfalls can be economically carried some distance.

Over air and water electricity shows its advantage in cost at the longer distances. Up to one kilometre cable transmission costs less, but from one to five kilometres electricity takes the lead, and retains it before all the others, including even gas.

In his Cantor lectures on hydraulic machinery, delivered before the Society of Arts in March, 1882, Prof. Perry gave an interesting and very complete comparison between the efficiency of the transmission of power by water and that of electrical transmission.

He said—To take the general case of transmission of power by water, Darcy's experiments tell us that each pound of water loses $f\frac{4\,L}{d}$ times its kinetic energy in flowing along a straight pipe of diameter d feet, length L feet, where f may be taken for a new 6in. pipe = 0 0058. Or if Q cubic feet of water flow per second, and if P was the original pressure in pounds per square inch, then ·262 P Q is the horse-power which enters the pipe, and ·0000665 L $Q^3 \div d^5$ is the power lost on the way. Thus, if E is the horse-power entering the pipe, the power lost is $\cdot 00025\frac{L\,E^3}{d^5\,P^3}$.

The tables at head of next column show the results with 6in. and 3in. pipes and different pressure.

With reference to electrical transmision, Prof. Perry said:—The law I have given you for the transmission of power by water is exactly the same as the law for electrical transmission:—The horse-power put into a pipe at the place A : the horse-power taken out of a pipe at the distant place B : : the pressure at A : the difference of pressure at A and B. So

Pressure, 700lbs. per Square Inch at Entrance.

Horse-power given in.	Horse-Power lost in 1 mile.		Horse-Power lost in 10 miles.		Horse-Power lost in 100 miles.		Horse-Power lost in 1000 miles
	6-inch Pipe.	3-inch Pipe.	6-inch Pipe.	3-inch Pipe.	6-inch Pipe.	3-inch Pipe.	6-inch Pipe.
500	·125	4	1·23	40	12·5	400	125
1,000	1·0	32	10	320	100	...	...
2,000	8·0	256	80	...	800	...	...
4,000	64·0	2048	640	...	...	...	...
8,000	4096	...	5120	...	...	...	...
16,000	...	...	...	...	...	...	...
32,000	...	...	...	...	...	...	...

Pressure, 1,400lbs. per Square Inch at Entrance.

Horse-power given in.	Horse-Power lost in 1 mile.		Horse-Power lost in 10 miles.		Horse-Power lost in 100 miles.		Horse-Power lost in 1000 miles.
	6-inch Pipe.	3-inch Pipe.	6-inch Pipe.	3-inch Pipe.	6-inch Pipe.	3-inch Pipe.	6-inch Pipe.
500	·015	·5	·15	5	1·5	50	15
1,000	·125	4	1·25	40	12·5	400	125
2,000	1	32	10	320	100	...	1000
4,000	8	256	80	2560	800	...	...
8,000	64	2048	640	...	6400	...	...
16,000	512	...	5120	...	...	...	...
32,000	4096	...	...	...	...	...	...

Pressure, 70lbs. per Square Inch.

Horse-Power given in.	Horse-Power lost in 1 mile.		Horse-Power lost in 10 miles.	
	6-inch Pipe.	3-inch Pipe.	6-inch Pipe.	3-in. Pipe.
500	15·6	...	156	...
1,000	125	...	...	...
2,000	1000	...	...	...
4,000	...	...	...	...

the horse-power going into a wire at A : the horse-power taken out of a wire at distant place B : : electric potential at A : the difference of potentials at A and B.

If P is the electromotive force or difference of potential in volts produced by a generator of electricity (this corresponds with pressure in water), E is the horse-power given by generator to wire.

$$\text{Horse-power wasted in transmission} = \frac{E^2}{P^2} 746\ R.$$

Now, for copper wire 1 inch in diameter, the resistance (R) of one mile is 0·058 ohm. Therefore, if l is distance in miles and d the diameter of the wire in inches:—

$$\text{Wasted horse-power} = \frac{E^2}{P^2} 746 \times \frac{0\ 058\,l}{d^2} = 43{\cdot}2\,\frac{E^2\,l}{d^2\,P^2}.$$

The following tables give an idea of the loss in transmission of power:—

Potential, 80,000 Volts.

Horse-Power given in.	Horse-Power lost in 1 mile.		Horse-Power lost in 10 miles.		Horse-Power lost in 100 miles.		Horse-Power lost in 1000 miles.	
	½-inch Wire.	¼-inch Wire.	½-inch Wire.	¼-inch Wire.	½-inch Wire.	¼-inch Wire.	½-inch Wire.	¼-inch Wire.
500	·007	·027	·07	·27	·7	2·7	7 0	27
1,000	·027	·108	·27	1·08	2·7	10·8	27 0	108
2,000	·108	·432	1·08	4·32	10·8	43·2	108·0	432
4,000	·432	1·728	4·32	17·28	43·2	172·8	432·0	1728
8,000	1·728	6·912	17·28	69·12	172·8	691·2	1728·0	6912
16,000	6·912	27·648	69·12	276·48	691·2	2764·8	6912 0	...
32,000	27·648	110·592	276·48	1105·59	2764·8	11055·9	...	...

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Potential, 8,000 Volts.

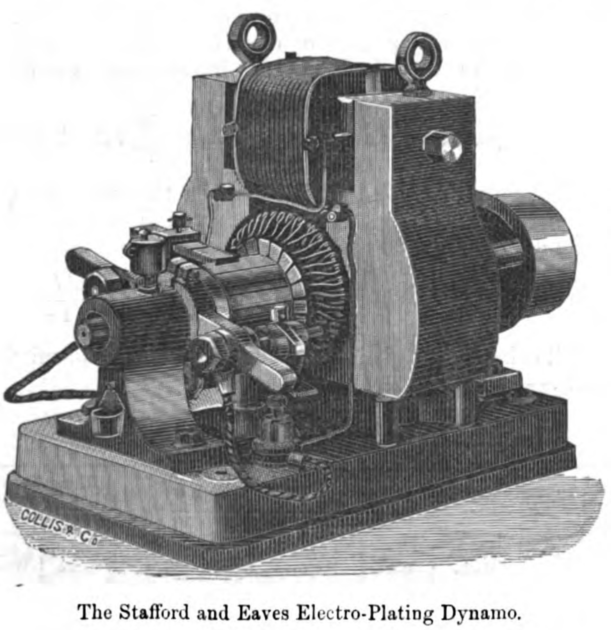
Horse-Power given in.	Horse-Power lost in 1 mile.		Horse-Power lost in 10 miles.		Horse-Power lost in 100 miles.		Horse-Power lost in 1000 miles.	
	½-inch Wire.	¼-inch Wire.	½-inch Wire.	¼-inch Wire.	½-inch Wire.	¼-inch Wire.	½-inch Wire.	¼-inch Wire.
500	0·7	2·7	7	27	70	270	...	...
1,000	2·7	10 8	27	108	270	...	...	...
2,000	10 8	43·2	108	432	1080	...	...	...
4,000	43·2	172 8	432	1728	...	...	...	...
8,000	172 8	691·2	1728	6912	...	...	...	...
16,000	691·2	2764·8	6912	...	...	...	...	...
32,000	2764·8	11059·2	27648	...	...	...	...	...

These comparisons as well as the data given in the preceding pages show that electrical methods have no cause to fear competition either as to cost or efficiency. The longer the distance and the greater the amount of power to be transmitted the more favourably does electrical transmission compare with other systems, but for this reason it has had a worse chance in early attempts than it would have had if its efficiency were greater on a small scale of distance and power.

The methods of working which are adopted in each case must of course suit the circumstances of the mine. The naked conductors of the Zaukerode pit would not suit a fiery locality, and they are not necessary. An electrical locomotive can be worked by means of storage batteries carried on the engine, and the danger of sparks from exposed conductors when short-circuited can be thus abolished. For stationery motors the conductors can readily be so protected that nothing short of a fall of the roof would cut them, and the sparking at commutators is rendered quite harmless by surrounding the commutators with wire gauze, practically running them inside the case of a safety lamp. The sparks being at any rate very different from a continuous flame give much less opportunity for any ignition of gas even if unprotected.

AN ELECTRO-PLATING DYNAMO BY STAFFORD AND EAVES.

Messrs. Stafford and Eaves, of Coventry, are the makers of a continuous current dynamo with Gramme ring arma-



The Stafford and Eaves Electro-Plating Dynamo.

ture, and field-magnet of the single horseshoe type, having a single coil wound upon the yoke. They turn out several different classes of this machine, adapted respectively for arc and incandescent lighting, and both for low and moderate speeds. This firm has, however, devoted its attention in an especial manner to the construction of dynamos for electro-plating and refining, and it is one of their machines designed for this class of work that we illustrate herewith.

This particular machine is a small one, having an output of only 900 watts, measuring 2ft. 5in. in length, 1ft. 6in. in breadth, and standing 1ft. 10in. high. At 640 revolutions it yields 6 volts at the terminals with a current of 150 amperes. The electrical efficiency is somewhat low, not exceeding 76 per cent. with full load, but the makers inform us that if it had been permissible to run the same machine at 1,000 revolutions the electrical efficiency would have been raised to fully 90 per cent.

As it is usually required in this class of work to keep the current (or rather the current density) constant, the E.M.F. is adjusted by means of a variable resistance in the field circuit. The total weight of the machine is 4cwt. 2qrs., which includes 260lb. of magnetised iron and 36lb. of copper. This corresponds to an output of two watts per pound of total weight, and 25 watts per pound of copper.

The magnets, which, as in all Stafford and Eaves' machines, are of the single horseshoe type, are of hammered scrap, weigh 210lb., and have a sectional area of 22·5 square inches. The pole-pieces are of cast iron. The following figures relate to the winding of the shunt coils :—

Length of wire	650ft.........	Amperes 12.
Diameter	·109in.	Turns 288.
Sectional arc	·00933in.......	Ampere turns 3,456.
Resistance as connected	·5 ohm	Current density 1,312.

The armature has an axial length of 5in., diameter 8·5in., radial depth 1⅝in. There are four circuits between the brushes, and the ring is wound with 80ft. of copper wire weighing 11lb., and having a resistance of ·0065 ohm. The current density in the armature amounts to 2,445 amperes per square inch, and the watts lost to 147. The air space, annulus, inter-field, or kinetic field (as it has been variously proposed to designate this locality), measures ⅝in. across, and the magnetic induction in the armature iron amounts to 20 (Kapp) lines per square inch. The iron in the armature weighs 50lb. These figures indicate an output of 81·8 watts per lb. of armature copper, and 0·23 volt per yard of armature conductor.

Coming, lastly, to the mechanical details, the bearings are fitted with solid gunmetal brushes 5in. long; the armature has a low peripheral speed, amounting to 1,424ft. per minute. There are eighteen pieces in the commutator.

This machine is capable of depositing about 4lb. of copper per hour, but the actual quantity will, of course, largely depend upon the surface of copper in the bath. The largest machine of the same type made by this firm absorbs 65 horse-power, and is calculated to deposit nine tons of copper per week.

We are not aware of the reasons which have induced the makers to adopt the somewhat peculiar shape of the field-magnets which will be noticed in the figure. It will probably occur to most electricians that the magnetic leakage might be diminished, and the induction through the armature probably somewhat increased, if the magnets were tapered off a good deal more than at present.

RESISTANCE OF FAULTS IN SUBMARINE CABLES.*

BY A. E. KENNELLY, M.S.T.E.

(Continued from page 487.)

The preceding tables seem to show that when the resistance of a break is steady for a particular steady current traversing it, of less than 25 milliamperes, the resistances it offers follow the law of inverse square roots of the current-strengths with sufficient accuracy for the purposes of measurement. The question that next arises is how this measurement can be best effected.

Two methods suggest themselves—one by deflections on a galvanometer placed between the cable and battery, the said deflections being reproduced artificially ; the other by Wheatstone's bridge. The bridge is perhaps the better means, because, although there is more trouble in arithmetically determining the proper testing current-strengths, still, with a dead-beat

* Paper read before the Society of Telegraph-Engineers and Electricians.

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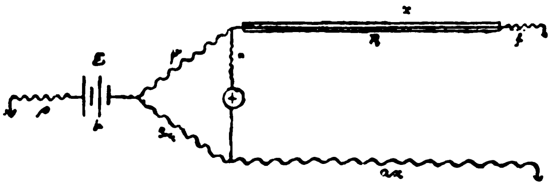
galvanometer, the false zero can generally be observed more quickly after the cessation of the testing current than in the deflection method. This, however, may be only a matter of opinion; but as all the observations in this paper have been by bridge, it will be better to here examine the bridge



method only. A cable of resistance R has its broken end offering a resistance f. The sum of these two—that is, the resistance observed with any given current—is represented by x. The arms of the bridge are μ and $a\,\mu$; so that a is generally unity, 10, or 100. The testing battery has an electromotive force E, and an internal resistance b. Between it and earth an adjustable resistance (ρ) is inserted, by which the strength of the current passing through f can be adjusted. It is better to add a resistance r to the circuit of the galvanometer if the latter be too sensitive, as, if balance be not attained, a shunt facilitates the increase or decrease of current to line beyond what is calculated for.

When balance is obtained, neglecting the electromotive force due to earth current or polarisation in the cable, the strength of the current leaving the battery is

$$\frac{E}{\rho + b + \dfrac{a(\mu + x)}{a+1}}.$$

Of this current the proportion going to line is

$$\frac{a}{a+1};$$

so that the current through the break is

$$\frac{E\,a}{(a+1)(\rho+b) + a(\mu + x)}.$$

In order that this current may be exactly n milliamperes this expression must be equal

$$\frac{n}{1000};$$

$$\text{from which } \rho = \frac{1000\,E\left(\dfrac{a}{a+1}\right)}{n} - \left(b + \frac{a\,\mu}{a+1}\right) - x\left(\frac{a}{a+1}\right).$$

On the right-hand side of this equation x and n are the only variables; so that for a given battery and bridge ratio the numerator of the first term, the whole second term, and the fractional part of the third term are constants. When the arms of the bridge are equal $a = 1$, and the equation

$$\text{becomes} \qquad \rho = \frac{500\,E}{n} - \left(b + \frac{\mu}{2}\right) - \frac{x}{2}.$$

When the arms of the bridge are in the ratio of 10, with the lesser on the line side, $a = 10$, and

$$\rho = \frac{909\,E}{n} - \left(b + \frac{10\,\mu}{11}\right) - \frac{10\,x}{11}.$$

The *modus operandi* is therefore as follows:—

Measure E in volts and b in ohms.

Fix upon the bridge ratio to be adopted.

If 100 ω to 1,000 ω is preferred, $a = 10$ and $\mu = 100$.

Find $909 \times E$.

Divide this constant by the numbers of milliamperes that are to be forced through the break; that is, divide by 1, 2, 3, . . . successively, up to 25.

From all the quotients subtract the constant

$$\left(b + \frac{10\,\mu}{11}\right) = (b + 91).$$

The differences remaining will be the values to give ρ in succession, after $\frac{10\,x}{11}$ (or, if x be not large, x itself) has been subtracted from them in turn.

Inasmuch as there will always be some polarisation, electromotive force, or earth current in the line, the actual current-strength through the break will not be exactly the amount calculated—generally less, in spite of reading to false zero. The best way to obviate this source of error is to make E as large as is convenient. For instance, if E be 100 volts, the current-strengths through the break will probably be correct to 2 per cent. A correction is, however, given at Appendix II. One direction of current only must be adhered to throughout the series, and it is better to use the zinc pole to line, as the hydrogen so developed on the exposure enters into chemical combination, and if freely discharged keeps its surfacee clean and uniform.

When a series of resistances has been observed in this way, the deduction of the break's resistance is a simple matter.

It is best to take an odd number of the readings in the neighbourhood of 4 milliamperes, and the corresponding quadruples—say, 3, 4, and 5, with 12, 16, and 20 milliamperes.

For instance, in the last table the resistance observed at 3 milliamperes was 1,828·2 ω
And the resistance observed at 12 milliamperes was 1,803·1 ω

25·1 ω

Now, by the law, the difference between these must be half the resistance the break offered at 3 miliamperes, and consequently the whole resistance it offers at 12 milliamperes.

Subtracting again, therefore, the distance of the break = 1,778 ω

Again, the resistance at 4 milliamperes was	1,823·1 ω	and at	5 milliamperes	1,818·1 ω
Again, the resistance at 16 milliamperes was	1,800 ω	,,	20 ,,	1,798·5 ω
∴ the resistance of the break at 16 mas. was	23·1 ω	,,	20 ,,	19·6 ω
∴ the distance of the break	= 1,776·9 ω		and	= 1,778·9 ω

The mean distance of the break from these three, = 1,177·9 ω

From this method of calculation it follows that more care is required for the observation of the quadruple than of the first current. For if the error in observing the resistance with a current c be a ohms, the error so produced in the result is a ohms; but the same error, a, in observing the resistance with $4\,c$ will produce an error in the result of $2\,a$.

Calculated in this way:—

Table V. from 5 and 10 milliamperes makes the break's distance 24·5 ω instead of 22 ω.

Table IV. from 4 and 5 milliamperes makes the break's distance 142 ω instead of 144 ω.

Table III. from 3 and 4 milliamperes makes the break's distance 600 ω instead of 598·6 ω.

The greatest error in the calculated distances of these three breaks would only have been 2·5 ω.

Table VII.

To further illustrate the method, the complete operations for arriving at the results given in Table VI. may be admitted.

Battery, 38 Leclanché cells (52·344 volts and 70 ω internal resistance). Bridge, 100 ω : 1,000 ω. Formula:—

$$\rho = \frac{909{\cdot}1 \times 52\,344}{n} - \left(70 + \frac{10}{11} \times 100\right) - \frac{10\,x}{11}$$

$$= \frac{47585}{n} - 160 - \frac{10\,x}{11}.$$

I. Current through Break. Milliamperes. Zinc to Line.	II. Constant (a), $\frac{47585}{n}$.	III. $a - 160$. $\frac{47585}{n} - 160$.	IV. First Approximation to ρ.	V. Corresponding Observation of x, corrected for Temp. Bridge.	VI. $\frac{10\,x}{11}$.	VII. Second Approximation to ρ. $\frac{47585}{n} - 160 - \frac{10\,x}{11}$.	VIII. Observed Value, x corrected for Temp. Bridge.
			Ohms.	Ohms.	Ohms.	Ohms.	Ohms.
1	47,585	47,425	46,000	1,900	1,726	45,700	1,888·2
2	23,792	23,632	21,900	1,850	1,682	21,950	1,833·2
3	15,862	15,702	14,000	1,828	1,662	14,040	1,828·2
4	11,896	11,736	...	...	1,657	10,080	1,223·1
5	9,517	9,357	...	...	1,653	7,700	1,818·1
6	7,931	7,771	...	...	1,647	6,120	1,813·1
7	6,798	6,638	...	...	1,646	4,990	1,811·1
8	5,948	5,788	...	...	1,645	4,140	1,809·1
9	5,287	5,127	...	...	1,643	3,480	1,807·1
10	4,759	4,599	...	...	1,642	2,960	1,805·1
11	4,326	4,166	...	...	1,640	2,530	1,804 1
12	3,966	3,806	...	...	1,639	2,170	1,803·1
13	3,660	3,500	...	...	1,638	1,860	1,802
14	3,399	3,239	...	...	1,637	1,600	1.801
15	3,172	3,012	...	...	1,637	1,375	1,801
16	2,974	2,814	...	...	1,636	1,180	1,800
17	2,799	2,639	...	...	1,636	1,000	1,799 5
18	2,643	2,483	...	...	1,636	847	1,799
19	2,504	2,344	...	...	1,636	708	1,799
20	2,379	2,219	...	...	1,635	584	1,798·5
21	2,266	2,106	...	...	1,635	471	1,798·5
22	2,163	2,003	...	...	1,634	369	1,798
23	2,069	1,909	...	...	1,634	275	1,797·5
24	1,982	1,822	...	...	1,634	188	1,797
25	1,903	1,743	...	...	1,634	109	1,797
26	1,830	1,670	...	...	1,633	37	...
27	1,762	1,602	...	...	1,633	...	...

Columns I., II., and III. are prepared before the test is taken.

For the first few observations preliminary approximations to the value of ρ have generally to be made, as the term $\frac{10\,x}{11}$ is not known; but after one

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or two readings the rate of change in x is soon detected, and the right value of ρ can be inserted by inspection.

With the battery and bridge ratio employed it was evidently impossible to push the readings beyond 26 milliamperes.

The criterion of a good series is the closeness of its readings to those of a second or repetition series respectively.

For the future, we may well entertain the hope that the law may equally be found to apply to results obtained by the deflection method of measurement. If so, scarcely any calculation would be needed; for so long as the currents sent from the battery do not exceed 25 milliamperes the resistances of the break would be in proportion to the square roots, inversely, of the observed deflections from the true scale zero, while the artificially reproduced deflections would be adjusted to the polarisation or false zero only. It would therefore be merely necessary to adjust ρ so as to obtain convenient deflections from true zero and their quadruples, then observing the false zero as soon as possible in each case, to reproduce by resistance the deflection from that false zero. The absolute current-strengths through the break would not be of consequence.

It may also be possible to extend the range of current-strengths that we can employ by experimentally arriving at an empiric series of currents above 25 milliamperes for whose components, and for a particular interval of false-zero reading, the rate of diminution in the break resistance will be determinable.

When a break is stated to have a certain resistance, it is generally understood that the resistance named is the estimated minimum which Lumsden's treatment with the particular battery and connections employed will produce. But if the exposure allows free discharge of gases, it is certain that under conditions which would force stronger currents through the break, this minimum would be still further reduced; and it is probable that this Lumsden's minimum, obtained at a time when the surface of the exposure is assumed to be free from gas or salts, corresponds to what would be obtained with a zinc to line series such as has been described, at the same current-strength, if it were possible to read to immediate false zero. Consequently, in order to convey an accurate or comparative idea of a break's resistance, it is necessary to mention the current-strength at which it was observed, and whether in a series, to a particular interval of false zero, or by Lumsden's method.

We may also hope, by collecting observations with broken cables, to predict for any given series observed, the length of conductor which will be found exposed. By experiments collected at Table IX. it appears that the resistance of one square centimetre of copper conductor to one milliampere, or what we may call more briefly the resistance per milliampere-square-centimetre, was about 70 ω. In Table II., the surface of a sovereign being about 8 5 square centimetres, the resistance observed per milliampere-square-centimetre seems to have been about 130 ω. Owing to impurity of surface, however, and to delay in false zero reading, the resistances of actual breaks referred to the unit area and current are greater. In the case represented by Table III. the exposure was observed to be about a quarter of an inch in length when the break was picked up, and in the case of Table IV. the exposure was found to be 0·9 centimetre long. The core was in both of $\left\{\begin{matrix}\text{120lbs. copper}\\ \text{175lbs. g. p.}\end{matrix}\right\}$ per knot; so that the exposed surface in No. III. would have been about 0·5 square centimetre, or from the observed readings 185 ω per milliampere-square-centimetre. In the case of No. IV. the surface would be about 0·7 square centimetre, and the observed resistance, calculated to the same unit, 145 ω. Selecting, in the absence of further data, the mean of these two as the resistance of the unit surface (165 ω), the area exposed in the broken end referred to in Table VI. would be $\left(\frac{165}{90}\right)^2$, or 3·4 square centimetres; and in the above-mentioned core this would be represented by 4·5 centimetres of conductor, linear measurement.

Returning once more to the theoretical side of the question, two interesting points present themselves for investigation.

1st. It appears from direct experiments, such as those shown at Table I., that for exposures artificially made, and with resistance but no electrostatic capacity in their circuits, the law of inverse square roots is only found to apply when the measurements are taken to immediate false zero. Even one second's delay seems to produce a large deviation. But in the case of actual exposures with broken cables the necessary delay of one second or more in observing the false zero does not apparently give rise to any great departure from the law. As one explanation for this very fortunate phenomenon, it may be suggested that the electrostatic discharge through the break upon the cessation of the testing current may so far influence the electromotive force of polarisation as to keep it from falling at the rapid rate observed in experimental exposures on short circuit. If this is the right explanation it should follow that the error would tend to increase as the cable became shorter; and the case of Table V., which has more error than the others, and refers to a cable broken only two miles off, seems to bear the generalisation out.

2nd. We know that when a metal plate is exposed in such a liquid as, for example, a solution of cupric sulphate, the resistance of the exposure is nearly constant for all currents. In fact, were it otherwise, it would follow that the internal resistance of a Daniell cell would vary with the strength of the current it generated.

On the other hand, all the experiments above mentioned go to show that the same plate immersed in salt water offers a resistance at its surface varying as the square roots inversely of the traversing currents, and thus apparently departing from what we might have expected by Ohm's law. The following experiment illustrates the matter:—

Experiment.

An exposure of about half an inch of No. 16 copper wire was immersed in sea water, and afterwards in a solution of copper sulphate. The resistances it offered to two series of currents—first with zinc, and then with copper to line, are shown comparatively.

The measurement was made by bridge, with 30 Minotti cells and a ratio of $\frac{100\ \omega}{1000\ \omega}$, in the manner described. All readings were to immediate false zero.

TABLE VIII.

I.	II.	III.	IV.	V.	VI.	VII.
	⅛″ Exposure in Sea Water.				In Solution Cu SO_4.	
Current through Exposure. Milliamperes	Zinc to Line.		Copper to Line.		Zinc to Line.	Copper to Line.
	Resistance observed.	Calculated Resistance from No. 4.	Resistance observed.	Calculated Resistance from No. 4.		
	Ohms.	Ohms.	Ohms.	Ohms.		
1	97	98	35	27	For all these currents the observed resistance was about 13·5 ω, slightly unsteady above 20 milliamperes.	
2	73	69·3	22	19·1		
3	55	56·6	16	15·6		
4	49	...	13·5	...		
5	42	43·8	11·9	12·1		
6	38	40	...	...		
7	36	37	...	...		
8	35	34·7	...	...		
9	33	33	...	...		
10	30	31	9·5	8·6		
11	28	29·5	Resistance, copper to line, suddenly increased above 10 milliamperes.	...		
12	27	28·3		...		
13	25·5	27·2		...		
14	24·5	26·2		...		
15	24	25·3		...		
16	23·5	24·5		...		
20	21	21·9		...		
24	19	20		...		
30	16·7	17·9		...		
40	15·2	15·5		...		
50	13·5	13·9		...		
60	12·5	12·3		...		

The figures in columns II. and III. show how closely the resistances, with the zinc pole to bridge follow the law of inverse square roots. With copper to line the law is not so well maintained, and broke off abruptly above 10 milliamperes; but with the exposure in copper sulphate solution the resistance with both currents was the same for 60 as for 1 milliampere.

The explanation of this difference in behaviour may lie in the fact that gas is developed on the surface of the plate in one case, and not in the other. The hypothesis may be advanced, in the absence of a better, that each bubble of gas, so long as it remains undischarged, undissolved, and not chemically reduced, may insulate the surface of the plate it covers; and that perhaps the rate at which this process of insulation disappears by the discharge of bubbles may be directly proportional to the square root of the quantities of gas developed in a given time, as these are known to follow the current-strengths directly.

But if these correlated laws of inverse squares connecting surface, resistance, and current recommend themselves to the Society on examination, and are corroborated by inquiry, it may well be anticipated that the true explanation of this interesting phenomenon will not long be forthcoming. Enough has been stated with the endeavour to show that besides the Lumsden method of estimating the resistance of a break, which will always remain in use, there is also an ample field open for measurement as a check upon judgment with the majority of breaks that present themselves in practice.

(*To be continued.*)

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the late meeting of the British Association on various subjects connected with Electrolysis:—

ON THE MIGRATION OF IONS AND AN EXPERIMENTAL DETERMINATION OF ABSOLUTE IONIC VELOCITY.

BY DR. OLIVER LODGE.

What may be considered as the greatest step in advance since the time of Faraday in the subject of electrolysis is due to Prof. F. Kohlrausch. His idea of specific ionic velocity is obviously most important. The bases of it are his own experiments on conductivity, and those of Hittorf on "migration" or unequal concentration.

Up to the present time the numbers given by Kohlrausch for the absolute velocity of different ions in centimetres per second have been deduced from theoretical grounds only, and the sole verification to which they have been subjected has been by showing that from them the observed conductivities and migration coefficients of a considerable number

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of solutions can be calculated. In a paper published last year* I indicated reasons for doubting the complete truth of the Kohlrausch theory as it stood, *i.e.*, for supposing it deficient in generality, and also initially suggested an experimental method suitable for examining the question, and for giving a direct determination of the absolute velocity of various ions, in a form apparently free from any hypothesis.

The method consisted in passing a current through an electrolyte contained in a uniform glass tube, and arranging some form of test substance to detect the position to which the ions had at any instant attained in their journey along the tube. The speed of any ion which lent itself to this mode of chemical detection could thus obviously be measured, provided disturbing causes could be excluded.

The experiments I have made on this plan hitherto, though numerous, can hardly be regarded as more than preliminary—a good many difficulties, some expected, some unexpected, having turned up in the course of the investigation, as usual. Nevertheless, a fair approach to a satisfactory and accurate result has been in some of the later instances obtained; and, besides the experience, some of the results themselves are worth having.

Let me first rapidly obtain the theoretical values of ionic velocity, in a complete manner, in order to distinguish the parts of the theory which are manifestly true from the parts which may require modification and development.

Consider a unit cube of electrolyte, containing n^3 *active* molecules, *i.e.*, n^3 molecules actually engaged in conveying a current, and ignoring any inert molecules such as those of the solvent have (perhaps without reason) usually been supposed to be. Let q be the total charge of each kind of electricity possessed by the constituent ions of each active molecule, and let U be the velocity with which the two oppositely charged ions are being sheared past one another by the applied slope of potential $\frac{dv}{dx}$. Then, if k is the conductivity of the unit cube, we have the following couple of expressions for the intensity of current (*i.e.*, quantity of electricity conveyed per second through unit area normal to the flow):—

First $n^2q \cdot n$ U, from simple notions of convection;

second $k\frac{dv}{dx}$, from Ohm's law.

Writing N for the number of monad gramme-equivalents *of the active substance* present in the unit cube, and η for the E.C.E. of hydrogen (that is, $1/\eta$ for the quantity of electricity corresponding to any monad gramme-equivalent), it is plain that

$$N \cdot \frac{1}{\eta} = n^3q.$$

So, equating together the above two expressions for intensity of current, we get

$$\gamma = k\frac{dv}{dx} = n^3q\,U = \frac{N\,U}{\eta};$$

or,

$$U = \frac{k}{N}\,\eta\,\frac{dv}{dx} = \frac{\eta}{N} \cdot \gamma; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

γ being the intensity of current.

Whence the arithmetic sum of the opposite velocities of anion and cation (u and v), when urged by a slope of potential of one volt per centimetre, through a solution containing N monad gramme-equivalents of active substance per cubic centimetre and of specific conductivity k seconds per square centimetre, is

$$U_1 = u + v = \frac{k}{N} \times \cdot 00010352 \times 10^8;$$

$$u + v = 10352\,\frac{k}{N} \text{ centimetres per second} \quad . \quad . \quad . \quad . \quad (2)$$

So far the ground seems to me to be perfectly firm.

We now proceed to apply this to special cases. To do this we *assume*, with Kohlrausch, first, that N = m, the quantity of salt in unit volume of the solution; second, that the ratios of the anion and cation velocities, u/v, are known for a number of substances from Hittorf's classical migration experiments. On these two assumptions a table of velocities can be constructed. They vary, it is true, with k/m, but this number is fairly constant for very dilute solutions of many substances; if it is not, the concentration must be specified.

The latest determinations of Kohlrausch give the following numbers for specific ionic velocities (in centimetres per second) in an aqueous solution containing one-tenth of a gramme-equivalent of salt per litre, the applied E.M.F. being 1 volt per centimetre:—

Cation . .	H	K	NH_4	Na	Li	Ag	½Ba	½Mg	½Zn
$v=$	·00300	·00057	·00055	·00035	·00026	·00046	·00033	·00029	·00026

Anion . . .	OH	Cl	I	NO_3	ClO_3	$C_2H_3O_2$
$u=$	·00272	·00059	·00060	·00055	·00046	·00029

Radicles omitted from this table, like SO_4, PO_4, &c., are intractable or anomalous.

Now in the above calculation what is there hypothetical? Accepting for the present the direct Hittorfian view of migration, the assumption that N = m involves two hypotheses, viz.:—

(1) That the added salt alone is the active substance, the solvent conducting none of the current.

(2) That the whole of the added salt is equally active.

On any dissociation view of electrolysis it could hardly be expected that when two substances are mixed one should be wholly inert, the other wholly active. It would seem much more probable, without evidence to the contrary, that the two substances should dissociate each other in some ratio or other, and that the conduction should be shared between them.

If this be so, equations (1) and (2) still remain perfectly true, but it is not so easy to determine N, the amount of active substance per cc. It may, indeed, turn out to be *proportional* to m, the amount of salt added, but it is hardly likely to be exactly *equal* to it.

Moreover, if two substances are active, we shall have to split up u into u_1 and u_2, v into v_1 and v_2, as well as N into N_1 and N_2.

If m is the mass of salt contained in every gramme of solution, $\frac{N_1}{m}$ is the "dissociation-ratio" or "activity-coefficient" of the salt, and $\frac{N_2}{1-m}$ the dissociation-ratio of the water. And equation (1), written out fully, becomes—

$$N_1(u_1+v_1) + N_2(u_2+v_2) = k\eta\,\frac{dv}{dx} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

The value of k to be used here is the simple straightforward conductivity of the whole solution. There is to be no subtracting of hypothetical water-conductivity in order to get at an inaccessible salt-conductivity; the distinction between known and unknown quantities is perfectly definite.

By a complete quantitative electrolytic experiment, such as Hittorf first made, and Wiedemann and others have followed up, the four quantities N_1u_1, N_1v_1, N_2u_2, N_2v_2 can all be obtained; but it is not possible thus to obtain the values u_1, v_1, u_2, v_2, separately, unless the dissociation-ratios N_1/m and $N_2/1-m$ are known too.

The mode in which I have begun to make complete determinations of electrolysis may be stated for the case of copper sulphate. The cathode vessel is in the form of a specific gravity flask with a long horizontal tube neck, which has a constriction at one place, to which it can be accurately filled, and an open mouth above the constriction for the anode vessel to dip its beak into. The cathode can be a piece of platinum fused through the glass, or, more conveniently, passed through a stopper. The anode vessel may be like a tobacco pipe with anode immersed in its bowl, and its stem recurved so as to dip into mouth of cathode vessel. Only one of the two vessels is to have measurements made upon it, and the cathode vessel is perhaps generally the more convenient. It can be kept immersed up to its neck in a bath of water at constant temperature (*See* Fig. 1).

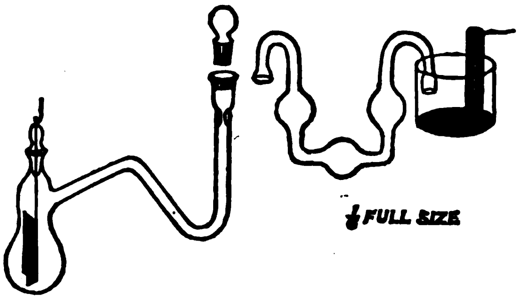

FIG. 1.

The course of experiment is as follows:—Fill cathode vessel with a standard solution, adjusting its level exactly to the mark at a known temperature; then weigh it. Pour a little more solution into its mouth. Fill anode vessel also with same solution; arrange as in figure, and pass a measured current for a known time, with a silver voltameter in circuit. Then remove anode vessel, readjust level in the other, and weigh again. Finally analyse the contents of the solution in cathode vessel, and weigh cathode deposit or voltameter plate. The necessary and sufficient data are these:—

1. Proportion of original ingredients in solution.
2. Initial weight of cathode vessel.
3. Final weight of ditto.

4 and 5. Any *two* of the following three things:—The amount of Cu, or of SO_4, or of free H_2SO_4 in the final solution.

The object of the long tube is to be sure that the current shall have to travel through the unaltered original solution in some part of its course.

I was under the impression that this scheme of experiment was more complete than any that had been previously attempted, but I have since looked up Hittorf's papers*, and found them very admirable. I do not say that nothing better can be done, but I have done nothing better yet, and, therefore, shall not at present rehearse the mode of treating the above data in order to extract from them their meaning, especially as it is long enough for a separate paper.

(*To be continued.*)

AUTOMATIC ELECTRIC GAS LIGHTERS.

Messrs. Woodhouse and Rawson send us a pamphlet describing various forms of automatic gas lighters. The lighting is effected by a spark from a small induction coil, in the same way as in the well-known portable electric gas lighters; but in these cases a permanent attachment is supplied for each burner, and the gas is turned on and set alight by the same opera-

*Aberdeen British Association *Report*, p. 754.

* *Pogg. Ann.*, Vols. LXXXIX., XCVIII., CIII., CVI.

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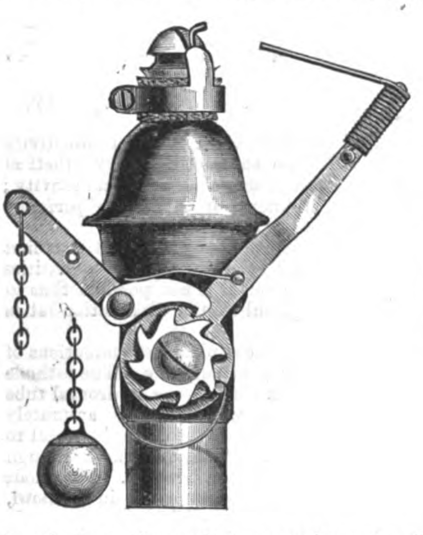
tion. The apparatus has been designed in several different forms. The type shown in the figure is actuated by a pull on the pendant chain, which turns on the gas through a four-way gas-cock, governed by a ratchet wheel and pawl. The issuing gas is lighted by a spark from the wire on the right, and the current is shut off as the chain is allowed to rise. Alternate pulls extinguish the gas. In a second form the operation is effected by turning a stop-cock in the ordinary way. In a third type the gas may be lit or extinguished from any distance by pressing a push button. In this case the stop-cock is worked by a vibrating make-and-break, and four to six Leclanché cells are required. These devices will often be found extremely useful where large numbers of gas jets have to be lit, and even



for private residences their convenience is sufficiently obvious to ensure a due appreciation.

A novel form of electric gas lighter has been brought out in America, depending upon the principle of the electrophorus. It seems doubtful whether such an instrument would work satisfactorily in this climate, but their success in New York seems to be unquestionable. The instrument is described as follows :—"It consists of a metal framework, pivoted to which is a metallic disc, on the under side of which is attached a sheet of tinfoil. This disc rests against a flat rubber frame, on the other side of which is a metallic disc, which connects with the metal rods, and from the rubber frame runs a rod of rubber between the two metallic rods. In one of the metallic rods, at the top, is placed a small screw, which is adjusted so as to project towards the rubber rod, and come within about ⅛th of an inch of a metallic point placed opposite in the hard rubber rod. By raising the tinfoil disc from the hard rubber disc, electricity is immediately generated, and a spark is at once formed between the end of the brass screw in the rod and the metallic point in the hard rubber rod. Just as often as the metallic disc is brought in contact with the rubber disc and separated, just so often will a spark be generated, and each spark is capable of lighting the gas. The great advantage of this extremely simple form of apparatus arises from the fact that a spark will always be generated in wet or dry weather. By an occasional momentary chafing of the rubber disc with tissue paper, and a little vaseline once in a while, the lighter is kept in perfect working order. There is practically nothing to wear out."

THE ELECTRIC LIGHT AT THE ROYAL EXHIBITION, NEWCASTLE-UPON-TYNE.

The electric lighting of the Exhibition has been placed under the superintendence of a committee of specialists appointed by the Executive Council. As soon as the erection of the building had been fairly started, the committee determined upon the distribution of the lamps in the principal courts and picture galleries, and invited tenders for the erection and maintenance of the installations. It was from the first the opinion of the committee that several systems of lighting should, if possible, be shown, so that the installations might form an interesting exhibit in addition to furnishing the light required. A considerable number of tenders were received ; some for small sections of the Exhibition only ; others for the whole amount of lighting required. Eventually five tenders were accepted, each system possessing its own characteristics, and the whole constituting a very important exhibit, while the means of making exact measurements of the relative efficiency of the dynamos employed will be provided.

The total area occupied by the buildings and gardens of the Exhibition is about 30½ acres. Of this amount the building itself covers a little over 200,000 square feet, and is constructed so as to enclose a garden of about 2½ acres. The garden is surrounded by a verandah, and will be lighted with twelve arc lamps, while 100 incandescent lamps will be arranged around the verandah, and about eighty lamps in the central band stand. The main building consists of courts 50ft. wide, and 30ft. or 35ft. high, with T falls 20ft. wide at the sides. These T falls are too low to be conveniently lighted by arc lamps, and to avoid the contrast of arc and incandescent lamps in close proximity it was decided to light the whole of the interior of the building by means of incandescent lamps, a little more than 100,000 candle-power being provided for the main courts. The engine room is situate about 100ft. from the north-west corner of the building, and will be lighted by eight or nine arc lamps. A few arc lamps will be placed in certain buildings in the North Gardens, while the North Gardens themselves will be lighted by about 53 arc lights, including six on the old Tyne Bridge. Two arc lamps will be placed outside the theatre, and two in each turret above the principal entrance. The royal reception room will be lighted by 18 incandscent lamps, and about 40 lamps will be arranged beneath the porch at the principal entrance.

The lights in the picture gallery are specially arranged for the illumination of the walls. In all, 400 lamps of 16 candle-power are employed, and are arranged upon specially constructed wooden frames, which are rendered fire-proof by being painted with white silicate paint, a preparation which is a more intense white than asbestos paint, and appears to be equally good in resisting fire. The wire connections to these lamps are covered with asbestos, and a short time ago the writer held one of these wires in his hands while a current of about 100 amperes was sent through it, which melted the copper throughout its length, but the asbestos so completely protected the hand that it was found possible to grasp the covering while the wire was melted and until it had cooled down again. The same kind of wire is employed for the lamp connections in the dining rooms and theatre, and is supplied by Messrs. Phillips Bros., of Hackney Wick. In all cases short lengths of tin wire are introduced into the circuits of every large lamp or every small group of 16-candle lamps, so arranged that the tin wire would fuse before transmitting a current which would appreciably heat the finest copper wire employed in the lamp connections.

In the theatre a very elaborate system of resistance coils is arranged, by means of which the lights in the auditorium can be lowered from 16 candles to about 1 candle, so as to produce a general dim illumination where stage effects require the theatre to be nearly dark. The foot lights and the top lights on the stage can be similarly controlled, and reduced from 16 candles to 6 candles or 1½ candle at pleasure. This is effected by causing the current to pass through coils of wire placed in the open air, outside the theatre. The liability to raise and lower the light in the theatre necessitates a special arrangement for keeping the electromotive force constant upon those lamps which are required to burn uniformly. This consists of a pair of return wires from the theatre to the engine, and the current through these controls an electrical governor, which in turn controls the valve gear of the engine. The governor is the invention of Mr. Richardson and Messrs. Robey and Co., and the engine is fitted with Pröell's valve gear. To guard against accident, lamps have been fixed in the theatre in connection with the picture gallery circuit, and with one of the circuits supplying the South Court, and these can be switched on at any moment, either from the stage or the box office, so that three accidents must occur simultaneously to throw the theatre into darkness. The lighting of the picture gallery, dining rooms, and theatre has been carried out by Messrs. J. H. Holmes and Co., of Newcastle-upon-Tyne, and the arc light outside the theatre and in the projection lanterns on the stage are the invention of the same firm.

The lighting of the principal courts of the Exhibition has been carried out by Messrs. Clarke, Chapman, Parsons and Co., of Gateshead. Their engine is a steam turbine, or series of steam turbines, to the shaft of which the armature of the dynamo is directly coupled, so that engine and dynamo stand on one bed-plate, and a machine capable of producing the same output as a dynamo and engine of 50 indicated horse-power occupies a floor space of only 10ft. by 1ft. 6in. There are 17 of these combined engines and dynamos in the Exhibition, 14 being placed together in the engine room, and three in the western annexe. Of these eight have a nominal output of 200 amperes at 110 volts, corresponding to nearly 30 electrical horse-power ; six an output of 200 amperes at 70 volts; and three an output of 150 amperes at 70 volts, making a total nominal output of 390 electrical horse-power, of which about two-thirds is required for the lighting of the building, and the remainder forms a reserve in case of accident. Separate circuits are introduced into every court, and the large lamps so arranged that the failure of a generator can cause the extinction of only the alternate lights. The very small size of the engines in relation to their output is accounted for by the very high speed, 9,000 revolutions per minute, at which they run. The steam is controlled by a very delicate magnetic governor, which opens or closes an aperture by which air gains access to a small bellows, while it is exhausted from the bellows by a small turbine on the shaft of the engine. The apparatus is lubricated by the automatic circulation of oil which becomes heated by the steam, and is cooled by copper gills or radiators, which are placed on one side of the bed-plate. Special flexible bearings are employed to render possible the very high speed attained by the engines.

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The lamps are also of special construction, the burners consisting of a bent rod of refractory material, varying in diameter from a little over one thirty-second of an inch to about one-eighteenth of an inch, according to the power of the lamp. The aggregate amount of light from these generators exceeds that of 100,000 candles, and the lamps are arranged in 28 separate circuits. Larger generators of the same type are sometimes made, but those shown may be regarded as the most serviceable for ordinary purposes, and the large number employed enables the electromotive force in each circuit to be adapted to the requirements of the group of lamps supplied, whether the distance of the lamps from the engine-house be great or small, so that there is no necessity to introduce artificial resistance for the purpose of regulating the lamps.

The same firm has gratuitously supplied the lighting for the Model Mine. An intense light is here purposely avoided. The lamps are of 16 candle-power, and are placed in air-tight fittings to protect them against fire-damp in the mine, which might possibly be exploded by the tiny spark which would occur if the connection of a lamp to the conductor were accidentally interrupted. To protect the conductors against damp, and also against falls of stones from the roof, the cables are encased in lead.

The small lamps at the principal entrance, and in the Royal reception room and offices, as well as those in the verandah and band stand of the inner garden, have been provided by Messrs. Paris and Scott, of Norwich. The current is brought into the main building by two separate circuits from the dynamos, which are placed in the engine house, and which, in common with all the other electric light machinery employed for lighting the building, except that of Messrs. Clarke, Chapman, Parsons and Co., are driven by Robey engines. The dynamos are constructed by Messrs. Paris and Scott, and show a very high efficiency. The conductors carrying the current to the central band stand are laid underground, and for this purpose are covered in lead, which protects their insulation from damp and mechanical injury. Besides the use of safety fuses Messrs. Paris and Scott employ magnetic cut-outs on their principal branch circuits. These cut-outs are of their own manufacture, and automatically break the circuit when the current is increased by 25 per cent. of its normal value.

The incandescent lamps in the Aylesbury dairy, and in the verandah and in many of the buildings of the North Gardens, including the Tyne Bridge shops, are supplied by Messrs. Nicholson and Jennings, of Old Kent-road. The lamps are of 16 candle-power, and the current is produced by Victoria dynamos, constructed by the Anglo-American Brush Corporation. Each of these lamps absorbs 60 watts, or nearly one-twelfth of an electrical horse-power. Altogether nearly 500 lamps are supplied from these dynamos. The arc lamps in the upper story of Messrs. Lockhart, Smith, and Co.'s Cocoa Palace are manufactured by Messrs. J. H. Holmes and Co., but are supplied and maintained by Messrs. Nicholson and Jennings. These lamps are placed two in series on the circuit of the Victoria dynamos. In common with the arc lamps supplied by Messrs. Woodhouse and Rawson they possess the unusual feature of working very steadily with a very small current when only a low illuminating power is required. One of these lamps has been made to burn steadily with only 1·25 ampere. The same dynamos of Messrs. Nicholson and Jennings are employed during the day in producing currents for motive power, but the arrangements for this will be described in due course.

The arc lamps in the gardens and in some of the buildings in the North Gardens, as well as the powerful lamps in the turrets above the principal entrance, are provided by Messrs. Woodhouse and Rawson. All the lamps in the gardens are of 2,000 nominal candle-power, and absorb 500 watts, or just over two-thirds of an electrical horse-power.

The lamps in the turrets take a current of 20 amperes at about 50 volts, and thus absorb 1,000 watts each. They are of the type known as the Diamond arc lamps, and the current for them will be furnished by two Elwell-Parker 50-unit dynamos, running at 450 revolutions per minute. Either of these machines will be capable of supplying the whole number of lamps, so that one will be a spare machine, but generally they will both be running together. The field-magnets are wound compound, so that when the external circuit is broken the E.M.F. of the machine is 200 volts. When all the lamps are on the E.M.F. is 220 volts, increasing with the output of the machine so as to compensate for the loss of potential due to the resistance of the leads, and keep the E.M.F. constant on the lamps.

Systems of lighting by means of transformers will be illustrated by Messrs. Woodhouse and Rawson and Messrs. Paris and Scott. The former will supply a 300-volt alternating Gramme machine, which will furnish current to a transformer of the induction coil type; the latter will exhibit a continuous current dynamo, furnishing a current at 800 volts, which will be employed to drive a "motor-dynamo," from which a continuous current at 100 volts will be obtained.

Messrs. Woodhouse and Rawson are also the contractors for the electrical tramway.

ELECTRICITY AT HATFIELD.

All the principal rooms of Hatfield House are now lighted by Swan lamps, including the Marble Hall, King James's Drawing Room, the library, the winter dining room, the chapel, the grand staircase, the long gallery, and the billiard room. Great taste has been displayed in the arrangement of the lamps, whether single or in clusters, the Elizabethan mouldings and pendants of this historic mansion lending themselves very artistically to this purpose, and advantage having been everywhere taken of this adaptability. Thus no special fittings out of keeping with the rooms have been used. In the Marble Hall there are nearly 500 lamps suspended, in the winter dining room 224, in King James's Drawing Room 110, the other rooms named being supplied in proportion. In addition to the lamps in these rooms the system is being extended to the offices and the basement of the house, and when the whole installation is completed there will be nearly 2,000 lamps in use. On the estate the operations at the Home Farm have been greatly assisted during the past and previous seasons by the use of the electric power, which has been applied in various novel methods. The "elevator" used to raise newly cut hay or corn sheaves to the top of the stack is of great service to the farmer. Dispensing with the usual horse or steam engine labour required for the machine, the "elevator" here is supplied with an electro-motor, fixed upon its bed, and driven by a current brought by wires from a central source. The wires are easily transportable, so that the "elevator" can be taken from stack to stack in a very short time. The greatest radius over which the electric elevator has been used at Hatfield is half a mile, being all that is there required; but of course the principle is capable of much greater expansion. Threshing was also carried on during the last season by the same application of electricity; wires conducting from the source of supply set in motion an electric motor, connected by a band to an ordinary threshing machine, no new gearing of any kind being required. In this way a six-horse threshing machine was driven by a current of ten amperes, having a force of 600 volts, dispensing with the use of a six horse-power steam engine. The electromotor and its threshing machine, as in the case of the elevator, are readily removable to a fresh stack. Ensilage has also been carried on with success at Hatfield, and here again the electric power has been laid under contribution. By means of an electro-motor connected with an ordinary chaff-cutting machine, rough grass was cut up for ensilage in several fields extending to a distance of nearly two miles from the source of power. The silos having been erected in a disused farm building, it was necessary to raise the grass to a height of some 20 feet, and the same motor which drove the cutter was also pressed into the service of elevating the grass to the top of the silo. The power similarly applied is also constantly used at the farm house, half a mile distant from the source of power, for grinding corn, barley, maize, beans, &c., for fodder, the grinding machine being driven direct by the electro-motor.

There are still other applications of electricity to be noticed at Hatfield. The house is supplied with water from a spring in the adjacent Conduit Wood, and all the water required above the level of the spring is pumped up by an ordinary Siemens motor, dispensing in this case with a considerable amount of manual labour. An equally useful domestic application of the power is made in connection with the ventilation of the house. One of Blackman's 48-inch air propellers is fixed in the roof, with an electro-motor to drive it, so that by the simple turn of a switch the ventilation can be regulated to a nicety. Some assistance towards the solution of that bugbear of rural life, the sewage question, has also been given by electricity. A large tank has been constructed in a field at a distance from the town, at a height of 30ft. above the level of the sewerage, and into this the town sewage is pumped up by a fixed Gramme motor, which will raise from 2,500 to 3,000 gallons per hour, the source of supply being in this case a Gramme machine, worked by a turbine, about half a mile from the tank. The sewage thus collected is readily available for irrigation. The power has also been largely used in connection with the River Lea itself, which supplies the water-power for the creation of the current. Pile-driving for making coffer dams has been carried on where necessary, an ordinary pile driver being worked by an electro-motor, which is readily removable as the work progresses. It has also been applied to dredging the river and clearing it of weeds, which grow thickly in the sluggish stream, the motor being placed on a barge, and turning an endless chain, extending from the barge to the bank, the hooks attached thereto dragging out the weeds and depositing them on the bank.

The water-power of the River Lea is, as said above, largely made use of in generating the electricity used for these very various purposes. Near Mill Green, the spot where the river flows into Hatfield Park, a turbine is placed which drives a Gramme machine, the power from this source being used in connection with the sewage tank, and being also available for the lighting of the house, nine furlongs distant, if required. Three-quarters of a mile below this point, and 1½ mile from the house, at the exit of the river from the park, the Lea is again utilised by two water-wheels of 16 horse-power and 40 horse-power respectively, the smaller one driving a No. 7 Brush machine for lighting the house and for the farming and other purposes above detailed, and also for working the machinery for making table ice. The large one drives a Siemens alternating current machine for lighting the house. These sources of power are supplemented by a gas and two steam engines placed near the house. The current is transmitted from the various sources to the house by insulated wires laid in wood-trunking, underground, while that for the various other operations is conducted by wires on poles. The whole of the current for the use of the house, though from various sources, is received at one point, where a switch-board is fixed, so that it can be diverted to any part required. The great economy in labour effected by the conversion of water-power into electric-power, and its transmission to any desired spot, need hardly be pointed out. The

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machines require comparatively little attention, and the attendance upon separate steam engines is entirely dispensed with. It only remains to add that the whole arrangements have been devised and superintended by the Marquis of Salisbury, and carried out in every detail by Mr. Shillito.—*Globe.*

COMPANIES' MEETINGS.

Western Counties and South Wales Telephone Company (Limited).

The second ordinary general meeting of the shareholders of this Company was held on the 6th inst. at the Royal Hotel, College-green, Bristol, Mr. C. Nash presiding.

The GENERAL MANAGER AND SECRETARY (Mr. H. F. Lewis) read the notice convening the meeting, and the report—of which the following is a copy—was taken as read:—The capital expenditure for the year ended the 31st December, 1886, has been £27,148. 4s. 8d., making a total of £66,501. 0s. 9d. to date. The gross revenue of the Company for the year 1886 was £15,406. 11s. 1d., against £12,540. 3s. 9d. for the period of sixteen months ended 31st December, 1885. The working expenses for the year have been £4,898. 17s. 10d., against £4,917. 5s. 2d. for the previous period of sixteen months. The balance of net revenue account is £3,853. 14s. 6d., which, after deducting the payment of a dividend of 6 per cent. on the paid up preference share capital to the 31st December, 1886, £2,095. 16s. 10d., leaves a balance of £1,757. 17s. 8d., and the Directors recommend a dividend at the rate of ½ per cent. for the half year ended 31st December, 1886, on the ordinary shares, which will absorb £687. 10s., and to place the sum of £410 to the special reserve fund, carrying forward the sum of £660. 7s. 8d. to next year. 25,000 ordinary shares still remain in the hands of the Directors to be dealt with in such manner as may be deemed desirable for the benefit of the Company. The remuneration of the Directors is left for the consideration of the shareholders. It will be seen from the following figures that the growth of the business of the company for the past year has been very rapid; the number of subscribers to the company's exchange system having more than doubled, whilst there has been a very satisfactory increase in the number of private line renters. The number of subscribers to the various exchanges and the number of private line renters on the 31st December, 1885, and on the 31st December, 1886 (including orders on hand) was as follows: Exchange subscribers: December 31st, 1886, 993; December 31st, 1885, 494—increase, 499. Private lines: December 31st, 1886, 325; December 31st, 1885, 239—increase, 86. Exchanges are in operation at the following places:—Bath, Bournemouth, Bristol, Cardiff, Clifton, Devonport, Gloucester, Landore, Llanelly, Morriston, Mutley, Neath, Newport, Paignton, Plymouth, Poole, Portsmouth, Swansea, Torquay. It is the company's intention speedily to open exchanges at Aberdare, Dorchester, Exeter, Great Malvern, Hereford, Merthyr, Newton Abbot, Pontypool, Pontypridd, Salisbury, Sharpness Docks, Weston-super-Mare, Weymouth, Worcester, &c. For several years the Swansea Telephonic Exchange Company (Limited) has carried on business at Swansea, but the directors have provisionally settled terms for the purchase of that company's business, and the agreement will be submitted for the approval of the meeting to which this report is presented. The Company have connected the following places:—Bournemouth and Poole, Bristol and Bath, Bristol and Cardiff, Bristol and Newport, Bristol and Sharpness, Cardiff and Newport, Cardiff and Pontypridd, Plymouth and Devonport, Plymouth and Mutley, Swansea and Landore, Swansea and Llanelly, Swansea and Morriston, Swansea and Neath, Torquay and Paignton. The following trunk lines are nearly completed and are expected to be opened by the 1st May:—Bristol and Aberdare, Bristol and Briton Ferry, Bristol and Gloucester, Bristol and Llanelly, Bristol and Merthyr, Bristol and Neath, Bristol and Pontypridd, Bristol and Rhondda Valley, Bristol and Swansea—these places will be in telephonic communication with each other as well as with Bristol. It is the Company's intention as soon as they receive sufficient support to connect the following places by trunk lines:—Bristol and Weston-super-Mare, Newport and Ebbw Vale, Newport and Pontypool—these places will be in telephonic communication with each other as well as with Bristol; Plymouth and Exeter, Plymouth and Torquay, Portsmouth and Bournemouth, Portsmouth and Gosport, Portsmouth and Southampton, Torquay and Newton Abbot, Weymouth and Dorchester, Worcester and Great Malvern. The Company have received numerous inquiries for a connection between the principal towns of their district and the metropolis; should circumstances warrant undertaking the expenditure they will proceed to make the necessary arrangements. The Directors are pleased to state that the relations of the Company with the Post Office officials continue to be of a friendly character.

The CHAIRMAN said the report and statement of accounts had been in the hands of the shareholders for some time, and he moved their adoption. He could congratulate his fellow shareholders on the satisfactory growth of the business. Only the previous day a very successful conversation was carried on between Bristol and Cardiff. There were two places where their success had been so great that he might mention them—Bournemouth and Torquay. They were both residential places, but the eagerness with which the telephone had been taken up there had quite astonished the Directors. The Company had not only been able to maintain the 6 per cent. on the preferential share capital, but they were able to pay one-half per cent. on the ordinary share capital.

Mr. MARK WHITWELL, deputy chairman, seconded the resolution, which was put and carried without discussion.

The CHAIRMAN then moved that in addition to the preferential dividend of 6 per cent. on the preference capital of the Company, a dividend at the rate of ½ per cent. for the half year ending 31st December, 1886, upon the ordinary shares of the Company issued at that date, be declared payable at the Company's bankers, Bristol, on 30th inst.

Mr. J. B. MORGAN (London) seconded the motion, which was carried unanimously.

The CHAIRMAN said the Directors had been very anxious to keep up their reserves. Last year a very fair sum was added, and he now moved that the sum of £410 be added to the reserve fund.

Mr. J. B. MORGAN seconded, and the motion was carried.

Messrs. J. W. Batten (London) and T. Pole having been re-elected Directors,

It was resolved, on the motion of Mr. J. INSKIP, seconded by Captain METHUEN, that the remuneration of the Directors be fixed at £300 a year.

Messrs. Tribe, Clarke and Co., and Messrs. Blease and Son were re-elected accountants.

An agreement for the purchase by the Company of the Swansea Telephone Company, on favourable terms, was ratified.

The proceedings then terminated.

CITY NOTES.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the two weeks ended 1st and 8th inst. amounted to £4,825 and £3,089 respectively.

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).—The Directors have determined, subject to audit, to recommend the payment of a dividend for the six months ended December 31st, 1886, of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year and a bonus of 20s. per share, both tax free, making in all 10 per cent. for the year. The dividend and bonus will be payable on and after May 1st next. The meeting of shareholders is announced for the 25th inst. at Winchester House, 50, Old Broad-street, at 12 o'clock.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ended 31st March amounted to £4,875.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended 1st and 8th April were £3,953 and £2,324 respectively.

THE JABLOCHKOFF AND GENERAL ELECTRICAL COMPANY.—At an extraordinary general meeting of this company a proposal is to be submitted to change the title to "The United Electrical Engineering Company."

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. April 13.		Business Done Week Ending April 13. Highest.	Lowest.
Anglo-American	36,	37	37	36½
Do. Preferred	58,	59	58¾	58
Do. Deferred	15,	16	15⅝	14⅞
Brazilian Submarine	10⅝,	10⅞	10⅞	10⅝
Cuba	11¾,	12¼	12¼	11 15-16
Do. Preference	18,	19	—	—
Direct Spanish	2¾,	3	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	9,	9½	9 5-16	9 3-16
Eastern Telegraph	10¾,	11	10 15-16	10¾
Do. 6 per Cent. Preference	13,	14	14	13⅝
Do. 5 per Cent. Debentures, 1899	104,	107	107	106
Eastern Extension	11⅞,	12⅛	12⅛	11⅞
German Union	9,	9½	9	—
Globe Telegraph and Trust	5⅜,	5⅝	5¾	5⅝
Do. Preference	12½,	12¾	12¾	12½
Great Northern	13¾,	14	14⅛	13⅞
Indo-European	35,	36	36	—
Reuter's	6¾,	7¼	—	—
Submarine	180,	190	—	—
West India and Panama	⅝,	⅞	¾	11-16
Do. 1st Preference	9¼,	9¾	9½	9⅜
Western Brazilian	7⅛,	7⅝	—	—
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Companies.	Closing Prices. April 13.		Highest.	Lowest.
Consolid. Telephone and Maintenance	¼,	⅜	⅜	—
Oriental	3-16,	5-16	—	—
United Telephone	12¼,	12¾	12⅝	12½

ELECTRIC LIGHT.

Companies.	Closing Prices. April 13.		Highest.	Lowest.
Anglo-American Brush Light (£3 paid)	2½,	3	2 11-16	—
Do. (fully paid)	3¾,	4¼	—	—
Swan	1⅜,	1⅝	—	—
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Companies.	Closing Prices. April 13.		Highest.	Lowest.
Telegraph Construction	35½,	36½	36¾	36
India Rubber, Gutta Percha, and Telegraph Works	22	23	22½	—

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NOTES.

The National Telephone Company.—Telephonic communication has now been established between the Falkirk and Grangemouth centre of the National Telephone Company and the Edinburgh and Leith centre.

Royal Institution.—Dr. John Hopkinson, F.R.S., being too unwell to continue his course of lectures on electricity, Prof. W. E. Ayrton, F.R.S., has kindly consented to take his place on Tuesday next, the 26th inst.

Rotterdam.—Messrs. R. E. Crompton and Co. are supplying through their agents in Rotterdam, Messrs. J. Van Zwieter and Co., one of their No. II. compound-wound dynamos, for the installation at Messrs. Baartz and Sons' Brewery, Rotterdam.

Lighting Tender asked for.—Tenders for illuminating certain streets in Windsor and Eton, on the occasion of the celebration of Her Majesty's Jubilee, are asked for. Particulars may be obtained from Mr. W. S. Long, Secretary of the Committee, 4, Park-street, Windsor.

Primary Battery.—Messrs. Bailey and Co., of Leather-lane, have recently shown us a zinc carbon primary battery, in which the carbon is of hollow tubular form, surrounding a zinc rod; the cells are bottle-shaped, and the plates are withdrawn by a hand-wheel on the top of the wooden case.

Christiana.—The Municipal Council of Christiana has refused two applications which have recently been made for concessions for lighting the town by electricity. A committee has now been appointed to consider a scheme for central station lighting, to be undertaken by the municipality itself.

Obituary.—We regret to announce the death, at the age of fifty-five, of M. A. Gaiffe, who was well known in France from his connection with the nickel-plating industry, which he was the first to introduce into that country. M. Gaiffe also occupied himself in the construction of apparatus connected with medical electricity.

The Julien Tramcar System.—The Julien system of electric traction will commence a regular service on the tramways at Brussels at the beginning of next month. The system is also to be brought into use at Rio de Janeiro. The cars have been built and equipped in Belgium, and will shortly receive a trial at Brussels.

Threatened Action on an Electric-Motor Patent.—It is stated that Messrs. Siemens and Halske have threatened an action against M. Julien at Brussels for an infringement of their patents in electric-motors. Apparatus concerned with the electric transmission of power has hitherto been singularly free from disputes of this character.

Abbreviated Telegraphic Addresses.—The Postmaster-General, having been urged by the Association of Chambers of Commerce to reduce the fee of one guinea now charged for the registration of an abbreviated telegraphic address, has replied regretting that he does not see his way to complying with the wishes of the association.

Earthquake Shocks in Jersey.—An Exchange Company's telegram from Jersey reports that a sharp shock of earthquake occurred there at three o'clock yesterday (Thursday) morning. The direction of the shocks was from west to east, and the duration lasted from three to five seconds. The people are much alarmed, but no damage is reported.

Turin.—A correspondent writes us from Milan as follows: "After a number of unsuccessful attempts to light a portion of the city of Turin with the Gaulard and Gibbs system, the original project had to be abandoned. The Zipernowsky-Déri system is now being used for the incandescent lighting, and the Thomson-Houston system for the arc lighting."

The Society of Telegraph-Engineers and Electricians.—The next meeting of this society will be held at 25, Great George-street, S.W., at 8 p.m., on Thursday, April 28, when a paper on (1) "Measuring the Coefficients of Self and of Mutual Induction," (2) "Driving a Dynamo with a very Short Belt," will be read by Profs. W. E. Ayrton, F.R.S., and John Perry, F.R.S., members.

Remarkable Railway Building Contract.—The Manitoba Railway Company having decided to build a new line 670 miles in length, a contract, which provides that the work shall be completed on or before November 23rd next, has just been concluded. To accomplish the task it will, of course, be necessary to push on the work day and night, and a very large amount of arc lighting will be required.

On Varnishing Incandescent Lamps.—Referring to the note upon this subject by Mr. Chevrill, which appeared in our issue of the 8th inst., the *Electrical Review* stated last week that a provisional specification for a similar process was filed in 1885 by Mr. Augustus Littleton, of Sydenham. Mr. Littleton's varnish was composed of the following ingredients:—Gum mastic, 22 parts; gum vandarac, 4 parts; ether, 200 parts; benzolo, 75 parts.

Vexio, Sweden.—The electric light is making some progress in Sweden. A central station has been started at Vexio, and is at present running 160 incandescent and 6 arc lights for the public lighting, and 500 lamps of 10 candle-power for house lighting. At Jonkoping a factory has recently been supplied with an installation of 700 lights. Several other towns, including Stockholm, have electric lighting projects now under their consideration.

The "Volta" Prize.—We consider it our duty to remind our readers that the competition for the "Volta" prize of 50,000 francs will be closed on the 30th June next, and manuscripts must be in the hands of the Secretary of the Institute at Paris before that date. The prize was offered five years ago (11th July, 1882) for the discovery of the greatest importance in the practical applications of electricity, and is open to all comers without any restriction.

Philosophical Society of Glasgow.—At an extra meeting of this society held on Wednesday last the following communications were made and experimentally illustrated:—1. "On a Double Chain of Electrical Measuring Instruments to Measure Currents from the Millionth of a Milliampere to a Thousand Amperes, and to Measure Potentials up to Forty Thousand Volts," by Sir William Thomson, F.R.S., past president. 2. "On Heat Radiation," by Mr. James T. Bottomley, M.A., F.R.S.E.

Antwerp.—A correspondent writes us that the *Palais Indien* at Antwerp has been supplied with an electric lighting installation, consisting of a 6 horse-power Körting gas engine, a Schuckert dynamo, 60 cells of accumulators (Gadot type), 50 incandescent lamps of 10 and 20 candles, and 20 arcs of 5 amperes. Unhappily the installation was undertaken with more haste than skill, and the motive power has proved quite inadequate to the work provided for it. This mistake has too often been repeated in Belgian installations.

Bournemouth.—The occasion of the first appearance of the electric light at Bournemouth, an event which we have already recorded as having taken place on Easter Monday, was rendered still more noteworthy by a dinner given on the following Wednesday evening by Messrs. Mortimer and Shepherd, at the Belle Vue Hotel, at which Mr. Shepherd is reported to have promised the inhabitants of Bournemouth the

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advantages of electric lighting at a cost not more than five per cent. in excess of what they now pay for gas.

ELECTRIC LIGHTING AT THE PARIS HOTEL DE VILLE.—For the lighting of the Hotel de Ville at Paris a very large secondary battery is being supplied. The battery weighs eleven tons (French) and contains 4,500 litres of liquid. The plates are of cylindrical form, 26cm. in diameter and 80cm. in height, and have a current-discharging capacity of 241 amperes. The number of elements is 165, and the output about 80,000 watts, rather more than 100 horse-power. The storage capacity is equal to about 1,000,000 coulombs. The battery is used as a regulator upon a circuit containing 2,200 Edison B lamps.

THE ROYAL SOCIETY OF EDINBURGH.—At a meeting of the Royal Society of Edinburgh on Monday, 18th inst., Sir Wm. Thomson, president, in the chair, the president read two papers—1. "On Ship Waves." 2. "On the Instability of Fluid Motion." The next paper was by Mr. D. S. Sinclair, Glasgow, "On an Experimental Research in Magnetism," communicated by Principal Jamieson. Mr. Sinclair discovers a formula to express the moment of a short iron bar in terms of the magnetising force, and predicts for such a bar the point at which the intensity of magnetism ceases to be proportional to the magnetising force.

KING'S COLLEGE, LONDON.—Prof. W. Grylls Adams, F.R.S., will deliver a course of lectures on "Electro-Magnetism," "Magneto-Electricity," "Electric Motors," "The Testing of Dynamos," "Electric Lighting," and "Transmission of Power," during the present term at King's College. A course of practical work in electrical testing and measurement with especial reference to electrical engineering will also be carried on under his direction in the Wheatstone Laboratory. The lectures will be given once a week—on Mondays at 2 p.m. The Wheatstone Laboratory is open daily from 1 to 4, except on Saturdays.

ELECTRIC RAILWAYS IN THE UNITED STATES.—The *Electrical World* of New York enumerates twenty-three towns in the States in which electric rail or tramways are now in actual operation; in some of these places two or three lines are at work. There are also more than a score of towns in which schemes of this character are seriously contemplated; so that our contemporary is able to point with reasonable complacency to the almost certain fulfilment of a prediction which it last year hazarded, namely, that before the end of the present year more than fifty electric lines would be at work in the States. This prediction excited a good deal of scepticism at the time.

BATH.—It is understood that several tradesmen in this town are making arrangements to celebrate the Jubilee by the introduction of the electric light. During the Jubilee week street illuminations on a large scale will be carried out by electricity. We also note that a resident in this town, writing to a local journal, states that he would gladly pay four or five times his present gas bill if he could have the advantage of a pure and wholesome light. If this gentleman speaks in sober earnest he should make inquiries as to the cost of an isolated plant; he would perhaps discover that the annual cost of a gas-engine, dynamo, and accumulators, all to himself, would not exceed the limit named.

THE TELEPHONE AT BRUSSELS.—We are informed that the real purpose of M. Gravet's recent visit to Brussels was merely in order to hasten on the arrangements now in progress for enabling the subscribers to the telephone system in Brussels to use the trunk wire to Paris. By the terms of the concession from the Belgian Government, it appears that the telephone company is bound at its own expense to introduce such improvements into the service as may be required to keep pace with the times. Experiments have for some time been in progress, with a view to determine whether any kind of relay can be successfully employed, or whether it will be necessary to use complete metallic circuits at Brussels, as at Paris, but no decision has yet been arrived at.

THE COMPARATIVE COST OF 1,000 WATT-HOURS.—A German writer publishes the following table as to the comparative cost of 1,000 watt-hours obtained by different methods:—

Daniell cell	2·12s.
Bunsen cell	3·02s.
Dynamo and steam engine	0·21s.
Dynamo and gas engine	0·50s.
Transformers at a distance of three kilometres.	0·28s.

It is a little difficult to see how the conditions in the last case can have been sufficiently generalised to make the comparison of any real value, but the figures at least serve to show the high estimation which is now being attached to transformer systems.

THE LIGHTING OF LEAMINGTON.—At a meeting of the Leamington Town Council the gas committee recommended the acceptance of the following proposition of the Midland Electric Light and Power Company: To supply and fix 55 new single standards, 12 new three-light standards, and to alter 92 existing lamp posts for the sum of £542. 10s. (such new and altered standards remaining the property of the Corporation) and further to light 183 lamps of 16 min. candle-power each, under the supervision of the borough surveyor, and during the hours the gas has been lighted during the past year, it being understood that 100 lamps only are to be maintained alight after 11 p.m., for the sum of £385 per annum, paid quarterly. This sum is to include renewal of lamps, cleaning, lighting and extinguishing, and keeping in repair, but not repainting the lamp posts.

MARRIAGE OF MR. F. E. BAINES.—The marriage of Mr. F. E. Baines, C.B., one of the assistant secretaries of the Post Office and Inspector-General of Mails, with Miss Laura Baily, eldest daughter of Mr. Walter Baily, M.A., of Auchmore, Haverstock Hill, was solemised at Rosslyn Hill Chapel on Wednesday last. A few days previously a handsome inkstand, accompanied by an address, was presented to Mr. Baines by officers of the Home Mail Branch, Mr. Sefton, the senior officer, recalling the services which Mr. Baines had rendered as Mr. Scudamore's right hand man in connection with the transfer of the telegraphs to the Post Office and their organisation afterwards. Other colleagues of Mr. Baines, including, we understand, Mr Stevenson A. Blackwood, the secretary of the Post Office, have also presented him with valuable tokens of their goodwill and esteem.

A QUERY IN MAGNETISM.—From the recent experiments of Prof. Ewing (to which reference was made in our last number) it appears that for the best Swedish wrought iron a magnetic induction approaching 32,000 lines to the square centimetre may be obtained—a number which exceeds the highest hitherto observed by something like 30 per cent. If, however, we assume that the point of absolute saturation has now been very nearly arrived at, it becomes an interesting question whether in fields of still greater density the permeability of iron would be negative. To make the question perfectly clear assume that a field could be created in air having a density of, say, 50,000 lines per square centimetre. If iron were placed in such a field, what would happen? Would the iron refuse to conduct more than a certain number of lines, squeezing the remainder into the surrounding space?

SCHOOLBOY DEFINITIONS.—We presume that many of our readers have seen Mark Twain's account of a "darling

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literary curiosity" in the *Century Magazine*—the genuine responses of American scholars to various questions asked in recitation; but four or five contributions to the exact sciences seem to demand that we should give them the benefit of our wider circulation. The following come together under the head of "Mathematics:"—

A straight line is any distance between two places.
Parallel lines are lines that can never meet until they come together.
A circle is a round straight line with a hole in the middle.
Things which are equal to each other are equal to anything else.
To find the number of square feet in a room you multiply the room by the number of the feet. The product is the result.

Among the contributions to physics are these:—

The weight of the earth is found by comparing a mass of known lead with that of a mass of unknown lead.
To find the weight of the earth take the length of a degree on the meridian and multiply by 62½ pounds.
A body will go just as far in the first second as the body will go plus the force of gravity, and that's equal to twice what the body will go.

An Experiment on Liquid Surface Tension.—The following curious experiment is described by Mr. Edward Blakeney, in the *Electrical World* of New York:—"In the bottom of a small glass tumbler is placed about ¼in. of mercury. A glass tube of ½in. internal diameter is suspended vertically in the centre of the tumbler, with its lower end dipping into the mercury, but not quite touching the bottom of the tumbler. A punctured copper disc is slid down over the tube. This disc serves as one of the electrodes, the mercury serves as the other. The tumbler is then filled with water. When, now, a battery of two or three cells is connected to the terminals, the mercury is seen to be somewhat agitated, and at the same time the water begins to rise in the tube. If the latter be not too high the water at last overflows, and the action continues, but if the tube be over two or three inches high there is a point reached where the water will rise no higher. This, undoubtedly, is the point of equilibrium between the weight of the water and the force which is acting upon it. It will be noticed that, in order to ascend the tube, the water must first find its way under the mercury. So far as I investigated the matter it appeared to me that the mercury took on a sort of vortex motion, drawing the water down at the tides and expelling it in the centre, thus filling the tube. When the action is continuous, the instrument might properly be called a vortex electrical pump."

Method of Distinguishing Between the Poles of Influence Machines.—In *Wiedemann's Annalen*, No. 5, 1887, Herr Otto Mund describes a very simple means of distinguishing the positive from the negative pole of an influence-machine. When the ordinary spherical electrodes of an influence machine in action, without a Leyden jar, are separated by a distance usually lying between ½ and 2 centimetres, the stream of violet-coloured sparks passing between the two poles may be observed to be bounded at one extremity by a strip of clear white light from 1 to 2 millimetres in length, and this strip is always found to be in the neighbourhood of the positive pole. This appearance is sufficiently distinct to be observed in full daylight, and therefore gives a simple means of distinguishing between the poles. The author has been unable to find any previous notice of the occurrence of this "positive strip of light," as he calls it, and he points out that the recent publica tion by Stein and Voss of somewhat elaborate methods for effecting the same purpose show, at any rate, that its practical importance for distinguishing between the poles of an influence machine is not generally known. The phenomenon is observed with equal distinctness when one of the poles is earth connected, and when both poles are insulated, but it does not occur with pointed or with non-metallic electrodes. If one of the metallic electrodes is spherical, and the other in the form of a flat disc, the strip of light is only seen when the spherical electrode forms the positive pole.

The Electrolysis of Alkaline Solutions.—M. Duter has observed that in the electrolysis of aqueous solutions of the hydrates of any of the alkalies the volume of oxygen disengaged is always sensibly less than half the volume of hydrogen. This discrepancy augments as the size of the positive electrode is increased in comparison with the negative. When a large sheet of platinum was used for the anode and a fine wire for the cathode, one volume of oxygen was obtained for *four* of hydrogen. It seemed probable, therefore, that some new oxygen compound was formed in the electrolyte, and, if so, probably the conditions which would most favour the continuation would be that of a very dilute solution traversed by a feeble current for a long period of time. An experiment was carried out on these lines. The electrodes were separated by a porous partition, and after a current of ·03 ampere had passed through the solution for several days some of the liquid around the anode was drawn off, and heated nearly to the boiling point. Oxygen came off freely "in the proportion of one-fifteenth of the liquid" (presumably by weight). And in repeating the experiment with each of the alkalies in turn it was found that the proportion of oxygen evolved was sensibly constant. The oxygen cannot exist in the form of a simple solution, for it is less soluble in the alkalies than in pure water. After the gas has ceased to come off from the heated solution, a further quantity is evolved in the addition of a small quantity of acid. It appears probable upon the whole that the oxygen exists in the form of a peroxide of hydrogen, and this conclusion might be tested by careful observation of the quantity of hydrogen evolved after the passage of a known number of coulombs.

Pyro-Electricity.—At a meeting of the French Physical Society, M. Duhem recently opened a discussion on the question of the connection between the phenomena of thermo-electricity and the electrification of a tourmaline when heated, which is known as pyro-electricity. According to an old theory of Gaugain, the co-ordination of the phenomena is not difficult. A plate of tourmaline, cut normal to the axis, exhibits when heated opposite electrification upon its two poles (which differ externally in the form of their faces), while the signs of the electrification change places when the crystal is cooled. Now, if the existence of this internal E.M.F is due to a cause similar to that which determines thermo-electric E.M.F., two conditions should be fulfilled. (1) A difference of temperature must exist between different portions of the tourmaline plate. (2) The structure of the plate must be heterogeneous. Both these conditions are evidently fulfilled. There is a difference of temperature between the inside and the outside of the plate, and the crystalline condition provides the required heterogeneity in the molecular structure. The phenomenon of piezo-electricity (or the development of the electric condition by subjecting certain crystals to compression) may also, according to M. Duhem, be brought under the same denomination if we consider the effects to be primarily due to heat disengaged during the compression of the crystal. M. Currie agreed that the phenomena of pyro- and piezo-electricity had a common origin, namely, the deformation of the crystal. But he could not admit that they were identical, or that the latter was due to the development of heat by compression. The amount of heat so developed was far too small to account for the observed degree of electrification.

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Students' Meetings at the Society of Telegraph-Engineers and Electricians.—The following circular, signed by the secretary, has been issued to the Students of this society:—"Dear Sir: I beg to inform you that, in compliance with the request of many of the students of the society, the council have arranged that a series of students' meetings shall be held in the library of the society for the following purposes:—1. Reading and discussing papers written by students. 2. Discussing papers read at the general meetings of the society. 3. Discussing questions of interest in connection with electrical science. These meetings will be held during the present year on the following Thursday evenings, unless an extraordinary general meeting of the society should be convened for any of them, in which case the students' meeting would not be held:—April 21, May 5, May 19, June 2, Nov. 17, Dec. 1, Dec. 15. The meetings will commence at 8 p.m. and will close at 9:30 p.m. Each meeting will be presided over by a member of the council or some other member of the society, but, with that exception, students only will be allowed to attend. A notice, stating what paper will be read, or subject discussed at each meeting, will be placed on the notice board, in the hall of the Institution of Civil Engineers, on the previous Thursday evening. Papers by students must be sent in to me, for the approval of the council before being read. Should any paper written by a student, and read at one of the students' meetings, possess, in the opinion of the council sufficient merit, it will be published in the society's *Journal*, and will be taken into consideration in connection with the award of the society's annual premiums. The meeting on Thursday evening, the 21st inst., will be held only for the purpose of electing a committee of the students, who will represent the whole body of students in any communication necessary to be made from time to time between them and myself."

Lightning at a Cable Office.—The *Monthly Correspondent* (a lively little journal published by the staff of the Brazilian Submarine Telegraph Company at Madeira) contains an account of a remarkable fault caused apparently by lightning on the night of March 12th. About 11 p.m. there came a dazzling flash of forked lightning, followed by a crashing peal of thunder, and at the same instant the staff on duty in the Madeira office were startled by a brilliant flash which issued from the line terminal of the wire communicating with the Portuguese Postal Telegraph Office, and extended apparently almost across the room. The whole of the lines were immediately earthed until the storm had passed over, and it was then found that no damage had been inflicted upon any of the lines or instruments with the exception of the line to Carcavellos and St. Vincent, upon which a total disconnection was found to exist. On testing the lines the fault proved to be local; nevertheless the continuity of the leads and the insulation of the condensers and coils were found to be in perfect condition. "It was enough," says the *Correspondent*, "to puzzle Kempe, Preece, and Culley all rolled into one, and more than one party scratched his head in dire perplexity. The only bit of the faulty circuit which had not been tested was the solid brass work of the office commutator, all changes in which are made with thick straps instead of with plugs. So here is a short shaft of brass, about the thickness of a finger and about 2½in. in length, extending through the ebonised board from instrument room to testing room," and, ridiculous as it seemed, yet to this point the fault had undoubtedly been traced. The brass shaft passed through a thick vertical slab of brass, and was secured by a brass nut screwed down upon the surface of the slab; underneath this nut a minute blister appears to have been raised upon the lacquer, for upon slightly scraping the surface the fault was completely rectified. This part of the circuit was situated between the instrument and earth, and there can be little doubt that the fault was due to the heating effect of the lightning discharge, although it is not a little singular that no other damage was done. What kind of lightning protectors were in use in the instrument room and how they behaved we are not told.

The Electric Lighting of the Glasgow Underground Trains.—At the eleventh ordinary general meeting of the Glasgow Philosophical Society on the 13th inst., Mr. T. P. Carswell, C.E., of the North British Railway Company's Engineering Staff, read a paper on "The Automatic Electric Lighting of Trains on the Underground Railway." We have already given a general account of Mr. Carswell's system, which is now being tried at Glasgow, but the following abstract gives some additional details. The particulars given as to cost are very noteworthy. The current generated by a dynamo at Queen-street Station is carried by a central, or third rail on the line, and is conveyed through pulleys and wires to the carriage lamps. The middle rail, which runs the whole length of the tunnel, is made of tee iron, and stands four or five inches higher than the ordinary line, on insulators of glazed fireclay about 5ft. apart. On the bottom of each carriage, at a height corresponding to the rail, are two contact-makers or pulleys of crucible cast steel, fifteen inches in diameter, hung on a centre so as to move horizontally, and having spiral springs which allowed them to rise three or four inches. Wires from the contact-pulleys are connected to two 16 candle-power Swan lamps in each compartment, one on either side of the ordinary roof lamp; but only one is lit at a time, the second being a reserve which automatically lights itself in the event of its neighbour failing. By this system the light appears whenever the train enters the tunnel, and disappears whenevers it leaves it; and, as there are no connections between the carriages, the train can be broken up or shunted in the usual way, while the light is maintained whether the carriages are in motion or at a standstill. The current is produced from a large "Crompton" compound-wound, self-regulating dynamo, at the Queen-street High Level Station, always kept running. In the central rail the current of electricity is so low in potential that some men touching it did not feel it at all, while others were slightly affected by it. The power required for each train was about 2,000 "watts," or from two to three horse-power. It is possible to have seven trains in all on the three circuits into which the tunnel is divided, the point furthest away from the dynamo being at a distance of one mile and a fourth. During the five months the trial had lasted, out of sixty lamps on two trains three had to be renewed, though two of these were maliciously destroyed. The cost of the system was a fourth less than that of either of the other two, and a third less than that of gas; while the working expenses, though about the same as the others, were a third beneath those of gas."

A Portable Hand Dynamo; and a Question of Self-Induction.—One of the smallest self-exciting dynamos which has come under our notice is a little machine made by Mr. G. Bowron (of 97, Crawford-street, W.), weighing 5½lbs., and from which, when driven by hand, an output of 12 watts can easily be obtained. This is not by any means a bad performance for a machine of the size, as we have described dynamos weighing (with their bed-plates) something like 50 times as much, and with no greater output per lb. of dead weight. This little machine has a Siemens shuttle-wound armature, with half an ohm of No. 22 wire, and provided with a two-part commutator; the magnets are shunt-wound to a resistance of 4 ohms. The commutator is made rather

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long, and the insulation strips are wedge shaped, so that different effects are produced by sliding the brushes to a different part. When the brushes rest on the part of the commutator where the insulation is narrowest the machine gives a tolerably uniform current; but when the wide part of the insulation is underneath the brushes the field is more or less demagnetised twice in every revolution; thus the E.M.F., although continuous in direction, undergoes considerable variation in amount. Under this adjustment the apparatus is therefore capable of performing the occult and mysterious *rôle* of a "medical coil." Mr. Bowron has noticed, notwithstanding the field-magnets are shunt-wound, that the machine will not excite when the brushes are on this part of the commutator, unless the external resistance is *below* a certain limit. This is a somewhat curious point; but it seems to us that the explanation is to be found in the following considerations:—It is known that the duration of the "extra current" (or, more strictly, the time occupied in falling to any given fraction of the first value) varies *inversely* as the resistance of the circuit, provided that the self-inductive coefficient remains constant. Therefore when the external circuit of the dynamo remains open the magnetism of the field has time to fall below the minimum required for self-excitation before the armature is again brought into circuit. As the resistance of the external circuit is reduced from infinity the period of demagnetisation lengthens until exciting power is recovered. This experiment seems to point to a method of investigating certain questions connected with the "variable period," which might prove of value, especially in the determination of the influence in this respect of Foucault currents—a matter which is not easily brought under calculation. For lecture purposes the experiment should also prove decidedly useful.

Electric Lighting at Hull.—At a recent meeting of the Sub-Property Committee of the Hull Corporation, Mr. White, the borough engineer, read the following report:—"The borough engineer, pursuant to the resolution of the 15th December, 1886, begs to report, with reference to a scheme of electric lighting for the Town Hall and the Market Hall, and the shops therein, that he is of opinion that such a scheme could only be adopted by a largely increased outlay over that involved in the use of gas, seeing that the only saving to compensate for the provision and working of an extensive plant would be the value of the gas requisite for lighting during a comparatively small number of hours each day. Should the Corporation, however, be of opinion that the advantages of the electric light over gas are sufficient to counterbalance such increased outlay, he considers that the buildings might be most advantageously let for one station, which might also be made available for the production of light for other purposes; but the Corporation do not seem to possess a suitable sight for such a station, and it would therefore be necessary to rent or purchase a site for the purpose. As regards the method of lighting the respective buildings, it appears that the most efficient and economical manner of dealing with the large spaces is by arc lamps, and for this reason it is assumed that the Market Hall and the entrance hall and banqueting room of the Town Hall would be lit by means of such lamps, and that in other cases incandescent lamps would be used. In calculating the cost of the installation, provision is made for electric light in the Town Hall to the same extent as when it was previously in use—viz., to the extent of five one-thousand candle arc lamps and 120 incandescent lamps, and in the Market Hall provision is made for four one-thousand candle arc lamps, together with 300 incandescent lamps in the shops connected therewith. The borough engineer estimates the first cost of such an installation at £4,000, exclusive of site for station, and the annual expenditure, including 10 per cent. on the above amount for interest and depreciation at £570, to which should be added the interest upon the value of site for station, say £25, making £595. The saving in gas alone by the adoption of the electric light to the extent indicated he estimates would not exceed £300 per annum. As to the production of lights for other purposes, he estimates the cost of duplicating the plant at £3,200, and the annual expenditure on account of the additional plant, including interest and depreciation, at £420." It was agreed that the report be printed and circulated, and considered at a future meeting of the sub-committee.

Methods of Starting an Arc without Contact.—It will perhaps be remembered that at a recent meeting of the Society of Telegraph-Engineers, Prof. Ayrton observed that he should like to make an experiment to see whether an arc could be started between two carbons not in contact by simply bringing a flame between them. Afterwards Prof. Silvanus Thompson said that he had tried this experiment both with a coal gas and with oxyhydrogen, without result; but he had found that a very minute spark sent between the carbons by a small induction coil, or by any static apparatus, was immediately followed by the full arc. Prof. Ayrton then suggested that the first experiment would probably have a better chance of success in rarefied air. These remarks have an additional interest in view of the fact that the *Comptes Rendus* for April 4th contains a note by M. G. Maneuvrier on the same subject, apparently written in ignorance of Prof. Thompson's experiments (which, it should be added, were carried out as long ago as 1878). M. Maneuvrier, however, not only describes the method of starting an arc by means of a small spark, but he has succeeded where Prof. Thompson failed, and finds it possible by means of a lighted candle to start an arc in the open air. The reason why the experiment did not succeed in the hands of Prof. Thompson is probably disclosed in M. Maneuvrier's remark that the arc commenced to play across "after a time more or less long." Success seems thus to have attended upon the experimenter who exercised the largest amount of patience. It does not appear that the temperature of the flame has much to do with the result, for the experiment succeeds better with a reducing than with an oxydising flame. This result suggests the explanation that the arc is carried across by the stream of carbon particles passing through the flame; although in that the element of time would appear to be chiefly, if not altogether, accidental. The maximum distance over which the experiment was successful amounted, however, to only 7 mm., even when the difference of potential produced by a Gramme alternating machine between the two carbons amounted before the formation of the arc to 500 volts. M. Maneuvrier has, moreover, discovered a third method of starting the arc without contact. The carbons are enclosed in a glass vessel, and connected as before with a source of alternating E.M.F. The air is then exhausted until a feeble "vacuum" discharge becomes visible; at this moment a stopcock is turned so as to admit a little air, and the arc immediately springs into existence. The first exhaustion need not exceed 5mm. or 6mm. of mercury, and the arc is produced when the pressure is again raised to somewhere between 30mm. and 150mm. The experiment may therefore easily be repeated with any common air pump. The distance between the carbons may be increased without difficulty to 25mm. or 30mm., and is, in fact, only limited by the E.M.F. at disposal.

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 479.)

Having now obtained all the required dimensions for the armature we can proceed to consider the external magnetic circuit. The problem before us here is the relation between magnetic induction and magnetising force. This difficult question has, as we mentioned at the commencement of these articles, received an immense amount of attention from various scientific men, among whom we specially named the Drs. John and Edward Hopkinson and Mr. Gisbert Kapp. It is upon Mr. Kapp's system, and for the sake of convenience, by aid of his own symbols, that the question will be here treated. Kapp's theory is based on an analogy in magnetic phenomena to the well-known Ohm's law; he accordingly represents the magnetic induction Z as the quotient of the exciting power P by the magnetic resistance R, this denominator being composed of the sum of three resistances R_a (the air gap), R_A (the armature core), and R_F (the external iron circuit), placed in parallel with a quantity, ρ, representing the resistance of the path of leakage.

The resistances both of the air gap and air leak are considered as independent of the number of lines passing through them. The iron resistances, on the other hand, are considered to increase as the quotient of the tangent of an angle representing the degree of saturation, which at 90° is supposed to be complete, this tangent being divided by the circular measure of the angle itself.

In this measure the initial resistance of a cubic inch of soft wrought iron, in which no induction is passing, is taken as 2 and cast iron as 3; the specific resistance of air is then found to be 1,440. This mode of dealing with magnetic problems is eminently practical, and is on that account, if for no other reason, invaluable to dynamo engineers, especially as the curves, when rightly calculated by its means, are found to agree with extreme accuracy with those plotted from direct observations.

Considered from a more scientific standpoint it would seem that the analogy has been pushed too far, and this view is specially forced upon us when we come to inquire into the constitution of the unit of exciting power.

For assuming the analogy to Ohm's law

$$P = Z\,R = \frac{Z}{\text{conductivity}}.$$

Now, if we consider the section of space enclosed by a circular current and occupied by some non-magnetic medium, such as air, by the aforesaid analogy the conductivity, being the reciprocal of resistance, which, like electrical resistance, is considered as inverse to the section, should be uniform over the whole surface; but this would entail uniformity in the distribution of magnetic lines, which we know does not exist.

The distribution of magnetic induction may be said to follow some function of the radius at any point, so that if we imagine the area as composed of elementary concentric rings, the radius will be subdivided into n elementary portions of r each.

The magnetic induction in the outermost ring will then be expressed by $2\pi C.(n-\frac{1}{2})r^2.\phi\{(n-\frac{1}{2})r\}$, where C stands for the current strength. The induction in the next ring will be $2\pi C(n-\frac{3}{2})r^2.\phi\{(n-\frac{3}{2})r\}$ and so on.

The total induction will thus be

$$S_M = 2\pi C r^2 \Big[(n-\tfrac{1}{2})\,\phi\{(n-\tfrac{1}{2})r\} + (n-\tfrac{3}{2})\,\phi\{(n-\tfrac{3}{2})r\} + \;.\;.\;.\;.\; + \tfrac{1}{2}.\phi\frac{r}{2}\Big].$$

It comes then to this, if we accept the analogy to Ohm's law in magnetic phenomena we must at the same time adopt the following convention with regard to the nature of magnetic conductivity, viz., that *the magnetic density in any point of a magnetised surface is the measure of the conductivity at that point.*

The conductivity will thus be expressed by the same series as the magnetic induction, and the quotient of the two quantities will be C.

We then have P = C, thus giving a single turn × unit current as the unit of exciting power. The above reasoning is not restricted to a circular coil, but will, of course, apply universally to any form, in all cases the unit of exciting power being independent of the perimeter.

The magnetic resistances of the various parts of the circuit are written as follows:—

$$R_a = 2\,\frac{1440\,\delta}{\lambda\,b},$$

where δ is the length of the air gap and $\lambda\,b$ stands for the polar surface; the numeric 2 is inserted because the lines have to pass twice across the length δ;

$$R_A = \frac{l}{a\,b},$$

where l is the length of the passage through the armature core and $a\,b$ the section of iron;

$$R_F = \frac{2\,L}{(A\,B)},$$

L being, as before, the length of the passage through the external iron circuit and (A B) the section.*

In the external passage we are only considering a single horseshoe, but in the armature core the lines divide and the two passages are considered in parallel; the factor 2 in the value for R_A is therefore unnecessary.

The leak resistance ρ, being a linear quantity divided by a square quantity, may be taken as inversely proportional to the linear dimensions of the machine, and is conveniently expressed by a constant divided by the diameter of the armature; this constant can be found for any type by a single experiment, as will be shown hereafter.

The application of the formula can perhaps best be explained by assuming a machine complete with the field-magnets, and then calculating by its aid the characteristic curve of magnetisation which would be produced by such a machine. We can then give Mr. Kapp's own words:—

"The only data (besides those taken from the drawing) which we require to know are—

"1st. Z_1. the maximum number of lines which can with an unlimited magnetising power be forced through the armature core.

"2nd. Z_2, the maximum number of lines which can be similarly forced through the magnet core.

"These are figures which depend on the dimensions of the cores and the quality of the iron, and if we could rely upon obtaining always the same iron, a few experiments made once for all would suffice for all future machines. Let the degree of saturation in armature and magnet be denoted respectively by σ_1 and σ_2, so that

$$\sigma_1 = \frac{z_1}{Z_1},$$

$$\sigma_2 = \frac{z_2}{Z_2},$$

Z_1 being the actual number of lines in the armature and Z_2 those in the field cores; then the actual resistance in the armature core is obtained by multiplying the initial resistance by

$$\frac{\tan\left(\frac{\pi}{2}\sigma_1\right)}{\frac{\pi}{2}\sigma_1},$$

and similarly for the field-magnet.

"From numerous experiments made with my own machines, and from data kindly supplied by some other dynamo makers, I am enabled to give the following average figures for the density of saturation to be taken as a basis when using my formulæ †:—

	Lines per square inch.
Armatures—charcoal iron wire well annealed ...	25
" " " discs " ...	22
Field-magnets—hammered scrap	18

* (A B) is treated as a concrete quantity in order to avoid after confusion when the single factors are used independently with other meanings.

† These figures are not to be taken as generally applicable, but simply as *averages* of the usual qualities of iron now obtainable.

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This gives us the values of Z_1 and Z_2. We now proceed as follows:—We assume a certain number of useful lines (z_1), and calculate the corresponding density (σ_1) in the armature core. The corresponding value of the function $\tan\left(\frac{\pi}{2}\sigma_1\right)\Big/\frac{\pi}{2}\sigma_1$ (taken from a table prepared beforehand) is then multiplied with the initial resistance of the armature core (R_A), and added to the air resistance. The sum is multiplied with z_1, and thus we obtain p_1, the quantity which we have called the magnetic pressure between the pole-pieces. The leakage of lines takes place under this pressure, and to obtain the exact number of the waste lines we must know the resistance of the space surrounding the machine. This resistance cannot be calculated in the same manner as that of the air space—so much depends on the configuration of the magnets on neighbouring portions of the iron bed-plate, bearings, &c.; but from the character of the resistance of a non-magnetic medium it is evident that for similar types of dynamos the value of s is inversely proportional to the linear dimensions of the machine. Thus this resistance can be found by dividing a constant by the diameter of the armature. An experiment made once for all is sufficient to determine this constant for all sizes of a given type. Knowing s, we find the waste field $\zeta = \frac{p_1}{s}$, and the total number of lines created $z_2 = z_1 + \zeta$. The ratio of z_2 to Z_2 gives us the density in the magnet σ_2, and by again referring to the table we find the corresponding value of the function $\tan\left(\frac{\pi}{2}\sigma_2\right)\Big/\frac{\pi}{2}\sigma_2$, with which the initial magnet resistance must be multiplied in order to obtain the actual resistance at that particular density. The product of this actual resistance with z_2 gives the exciting power (p_2) necessary for the field-magnet alone, and the sum of p_1 and p_2 is the total exciting power (P) necessary to produce z_1 useful lines. In this way we proceed to calculate P for various values of z_1, and, plotting the results in a curve, we obtain the characteristic of magnetisation, by the aid of which all the working conditions of the dynamo can be found."

In attempting to put the above system to a practical test there would, at first sight, appear to be some difficulty in finding out the numerical value of ρ, even though we might have a machine to hand of the particular type to which we wish to apply the formula. As a matter of fact, however, there need be no difficulty and little uncertainty in assigning this value. All we have to do is to plot the curve of E.M.F. with the machine separately excited, and with the armature on open circuit, taking care to carry the observation well on towards saturation. We can then gauge with practical certainty the horizontal tendency of the curve, which will give us the E.M.F. at which the magnetic circuit is saturated. The magnetic resistance of the armature at saturation point is, by the meaning of the phrase, infinite, and in Kapp's system is expressed by $\frac{2\tan 90^\circ}{\pi} . R_A$. To attain such a point, therefore, the section of the field-magnets must also be infinite, as the leak through ρ will be unlimited. In practice the section of field-magnets being finite, we may conclude that the armature core never is saturated; and, consequently, there being no restriction as to the saturation of the field-magnets, that the latter will at some point in the excitation overstep the armature core in magnetic density, *whatever may be their cross section.*

We thus see that the horizontal tendency of the curve denotes saturation in the field-magnets, and the estimated maximum E.M.F. is that at which we may assume actual saturation in them—then Z_2 will equal 18 A B.

(*To be continued.*)

TECHNICAL CRITICISM.

Our esteemed contemporary, the *Electrical Review*, contained last week some remarks (which will be found below) in criticism of a formula given by Mr. Guy C. Fricker in his papers on "The Practice of Dynamo Design," now appearing in our columns. To those who are at all familiar with Mr. Fricker's previous work in this direction it will necessarily appear in the highest degree probable that such criticism as this in question must be based either upon fallacy or misapprehension. It is, or should be, unnecessary for us to inform our contemporary that Mr. Fricker is as conversant with the practical as with the theoretical side of the question upon which he treats, and it is therefore somewhat surprising that his critic should consider it either safe or becoming to flourish the tomahawk and execute a war dance in such triumphant style without exercising the utmost precaution to ensure that neither fallacy nor misapprehension on his own part shall operate to mar the success of the onslaught.

We deem it superfluous to add any words of our own in defence of our contributor, who, in a matter of this simple kind, is perfectly well able to take care of himself; but on behalf of the scientific method in dynamo design, as opposed to the foot-rule process advocated by our contemporary, it may be as well to recapitulate briefly, in this place, the exact purpose for which the formula in question is intended to be applied. It will then rest with the critic, laying aside sarcasm, to show how the same thing is to be done with equal exactitude by the process which he recommends. We shall, however, confine ourselves for the present to the briefest statement of facts. A knowledge of the formula in question—which, by the way, is now published for the first time—is the necessary and sufficient condition for obtaining a solution *as exact as the present state of our knowledge admits* of the following problem:—To construct a dynamo of a given configuration, which at a given number of revolutions per minute shall have a given output; or, in other words, to determine the actual linear dimensions of the required machine from a knowledge of certain ratio values of its component parts. The complete solution is readily obtained when once the proper radius of the armature core has been found, and the formula which has excited the derision of our contemporary supplies this value in terms which are implicitly known from the conditions in which the problem is stated. Our readers will probably think that we have given an unnecessary amount of attention to this matter; but we have felt that so long as it is possible for a technical journal to contain a criticism of this order, it is our duty to protest against the idea that problems of this nature, involving as they must, in any case, the expenditure of much time, and thought, and money, should at any time be treated in the crude and unscientific style advocated by our contemporary, apparently for the sole reason that the scientific treatment involves the numerical solution of an admittedly somewhat lengthy formula.

The following is the article in question from the *Electrical Review*:—

"THE PRACTICE OF DYNAMO DESIGN."

A series of papers on the above, from the pen of Mr. Guy C. Fricker, is appearing in the columns of our esteemed contemporary *The Electrician*. In these papers we have in the formulæ a degree of simplicity hitherto unattained, as witness, for instance, the expression for the radius of the armature core where

$$R = 3{\cdot}6\left[\frac{E^2C^2(q+p+2\beta)}{\rho\beta(\mu p q \gamma n P M)^2(1-p-\beta)\{2(q+p)-qp-p^2\}}\right]^{\frac{1}{7}}.$$

We can sympathise with dynamo men in the expressions of surprise and regret to which they will give utterance when this remarkable formula meets their sight. Over the hundreds of dynamos constructed without its aid they will weep tears of remorse, and sigh in unspeakable regrets over the hours lost in applying a homely but unscientific foot rule for radii finding. If we are not mistaken, the new method can be explained by the help of an analogy. In the practice of modern shipbuilding it might be possible by a formula more or less involved to express in terms of the steam pressure the number of passengers which the vessel is capable of carrying. By a further algebraic development—simplicity itself—the area of the piston-rods might be accurately expressed as a function of the number thus found. Manifestly an expression so derived for the latter quantity would be of much greater service than a simpler expression in terms of the steam pressure and cylinder area, and no shipbuilder would hesitate to adopt the former in preference to the latter. In dynamo designing the indirect method should be similarly applied, and the more constants, coefficients, and variables we can cram into a formula, the more serviceable does it obviously become to the practical man. For this reason Mr. Fricker expresses the radius of the armature core in terms of "everything else," and this is, we repeat, the consummation of dynamo designing. The formula will, doubtless, be used by every maker, as the core radius

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can now be found by the mere shuffling and cutting once or twice of a round dozen or so of symbols.

Mr. Fricker has furnished us with the following copy of a reply which he has sent to our contemporary :—

[Copy.]

To the Editor of the "Electrical Review."

Sir: In your criticism of my papers on "The Practice of Dynamo Design" you endeavour to illustrate by sarcastic analogy the unnecessary and cumbersome character of my work.

If the work be really superfluous you are quite justified in being funny over it; but even then it would be as well to use a rational analogy. The one which you institute is based on the impossible hypothesis that the load on a steam engine might be expressed in terms of the steam pressure only, without reference to the size of the cylinders, and this is sufficiently absurd and futile without going any farther with it.

What I have done is to express the linear dimensions of a dynamo in terms of the general configuration of the armature, output, speed, and magnetic induction per unit area. These quantities constitute what is already known, and what may be assumed about the machine to be constructed; the linear dimensions are what have to be found. Most school boys would therefore understand that the proper and rational course would be to express the one unknown quantity in terms of the known quantities. You, however, would seem to suggest that some other course should be pursued, and that instead of making the linear dimensions fit the actual requirements of the machine, other quantities, such as the winding and magnetic induction per unit area should be made to fit the linear dimensions; thus the latter may be anything we please, and the final adjustment of the dependent quantities must be left to luck and to the application of the "homely foot rule."

I confess that I am not good at such flying shots, and should have hardly expected to have seen them advocated in a technical journal of the present day.

As a matter of fact, although the general expression which you quote is necessarily somewhat long and unwieldy, the practical form (which you carefully omit) in which it would be applied to a particular type, viz. :—

$$R = B\left(\frac{E\,C}{\mu\,n}\right)^{\frac{1}{3}}$$

is not such as to astound or mystify any dynamo maker with whom I am acquainted.—I am, sir, yours faithfully, GUY C. FRICKER.

9, Montserrat-road, Putney

SUBMARINE CABLES.—IV.

A statesman of a bygone period, whose speeches hold a classic position in political literature—we refer to Edmund Burke—tells us that "circumstances are infinite, are infinitely combined, are variable and transient; he who does not take them into consideration is not erroneous, but stark mad—*dat operam ut cum ratione insaniat*—he is metaphysically mad." A little further on in the same speech he says "Crude, unconnected truths are in the world of practice what falsehoods are in theory." It is just these crude, unconnected truths that we find it difficult to combat. One cannot deny a truth, and it is difficult to deny the relevancy of a truth. Thus we cannot deny the desirability of the reduction of the cost of telegrams, nor can we deny the desirability of further cable connections. What we do deny is that the destructive suggestions which have been made to compass these ends are good suggestions, and such as should commend themselves to men of business.

We contend that cable lines are somewhat analagous to railway lines, and consist necessarily of two great divisions, the trunk lines and the branch or feeding lines. When the commercial prosperity of a cable system is considered, the feeding branches are almost as important as the trunk lines. Glasgow, no doubt, is a very large and a very important town; but we doubt if it would pay to construct a railway with termini at London and Glasgow, but with no intermediate stations. The same applies, perhaps, still more forcibly to smaller and more distant places like Aberdeen and Inverness. Thus in railway management the main lines are taken, so as to keep the business of as many great centres of industries as possible, besides having branch lines leading to minor centres. The development of the cable system of the world has similarly followed this course, and whenever possible the traffic of the main lines is augmented by means of branch lines or feeders. We should hesitate, then, from a commercial standpoint, to support any scheme that pursued an opposite policy. We need not insist further upon this point, but take it for granted that our contention will not be disputed.

A few words as to alternative routes. At the present moment there exist alternative, and not only duplicate but often triplicate and multiplex routes to many a foreign trade centre, and also to many a colony. In the natural order of things it seems most probable for these alternative routes to increase; for example, the West African cable will sooner or later be continued from St. Paul de Loando southward, so that another route to the Cape is obtained, and not only to the Cape but to India, China, Australia, and New Zealand. Again, one need not assume the mantle of prophecy to foresee that land lines or cable lines will run northward on the West Coast of America, till at length a short cable junction will connect that part of America with the Asiatic Continent, giving still another alternative link to the telegraphing public. These extensions await the development of trade in the regions indicated, otherwise investors have no inducement to embark their money in cables to places where no trade exists and where none is likely to exist. If alternative routes are required for Imperial purposes they must be made at the expense of the taxpayer, and the links should be made in those directions where the expenses, if not the interest on the capital, would probably be obtained from trade development.

We shall now touch briefly upon the much-discussed question of traffic rates. This question must, like all the rest, be argued from a business point of view; and, in the first instance, when a cable line is laid, the management has to estimate the probable business and make its tariff accordingly. Subsequently the tariffs can be raised or lowered, as experience dictates. Usually, however, there is a cry to lower the rates, and great pressure is put upon the management to do so. There is seldom any desire on the part of the cable companies to overlook just claims; but the first duty of the management is certainly to obtain a fair return to the shareholders whose capital is invested in the undertaking. If it can be shown that the return obtained is out of all proportion to the risk, then, no doubt, the tariffs must be reduced. If, on the contrary, the return is fairly satisfactory, the shareholders cannot be expected to give what they have not to give. In other words, if the reduction of tariff leads to a diminished return, then the loss is wholly on the part of the shareholders and not upon the people who benefit most by the work. It is better to discuss this question in a specific manner, and we confidently appeal to our readers to support our conclusions from such a case as the following :—Given a cable system, paying its shareholders, say, 5 per cent., with a given tariff, and the traffic with such a tariff. Circumstances induce the management to lower the tariff, and they expect to recoup the loss thereby certain by an increase in the business. Time—an important factor in the discussion of this problem—is always required to enable the extra business to develop and recoup the loss, and during this time the returns of the system are less than under the previous conditions. The shareholders, and the shareholders only, are the losers. Why are they to lose in this way? Other business men are seldom placed in such a position as to be more or less in the power of Prime Ministers and principalities, and would object to bear such loss.

As we read the present state of affairs the cable companies do not relish the pressure brought to bear upon them to the deteriment of their shareholders, and suggestions have been made to the various authorities interested to this effect. The authorities may deem the matter of sufficient importance to lay a burden upon the taxpayers of the nation or the colonies generally by the payment of a subsidy guaranteeing a given interest upon the capital embarked in the cable enterprise. If this is done the cable companies have no objection to let the various authorities make their own tariffs. In time, no doubt, a great reduction of tariffs may develop trade sufficiently to pay the required interest and relieve the taxpayer. Meanwhile the taxpayer bears the loss. It seems to us that this plan is perfectly just. The shareholder evidently is not called upon to bear the loss; he is not a philanthropist, but a man investing his money to obtain a fair return, while, on the other hand, if the country or colony, as a whole, benefits by cable communication, the country or colony, as a whole, should pay for the benefit received. No doubt those interested will be able to lay their views before the

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members of the colonial conference far more fully than the space at our command enables us to do, and we therefore content ourselves with indicating the true lines upon which we conceive the development of cable communication should proceed.

WRECK OF THE TELEGRAPH STEAMER "VOLTA."

We regret to have to record the total loss of the telegraph steamer "Volta," belonging to the Eastern Telegraph Company—a loss more to be deplored in that it is not the loss of a ship only, but a disaster which has led to the sacrifice of several lives. The vessel went ashore in a storm early on Monday morning on the coast of the Bay of Panormos, off the island of Mykonos. Captain W. J. A. Dunn lost his life in the fruitless attempt to launch one of the boats. Among the others who have unfortunately lost their lives are Messrs. Blum and Windle, on the electrical staff, and about 12 of the crew. Mr. Simmons jumped overboard and managed to reach the shore, when he went straight to the telegraph office at Mykonos and sent word to Mr. Binney, the company's manager in the Levant, who started at once to the scene of the wreck with a steamer, and succeeded in saving a number of the crew, who were found clinging to the rigging. We are informed that the Greeks with Mr. Binney are deserving of all praise for their great and successful efforts in saving the lives of a number of the crew who were clinging to the rigging when the relief vesssel reached the scene of the disaster. Great praise is due to Mr. Simmons; and there is no doubt many lives were saved by his energetic action, for almost directly the men were taken from the rigging the masts were swept away by the action of the waves. Messrs. Aldrich, 2nd officer, and E. H. Draper, of the electrical staff, were washed overboard, but saved themselves by clinging to the floating wreckage, thus gaining the shore.

The following are the names of those known to have been lost by the disaster:—Captain Dunn, Messrs. Blum, Windle, Hill, Scott, Bone, Costi Cavilis, Lampier, J. Kriningas, V. Gallia, and Frank Gallia.

Full details of the disaster are not yet to hand, but we sincerely hope that the above list will not have to be extended.

CORRESPONDENCE.

THEORY OF SECONDARY CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With regard to Mr. E. Aldred Williams's letter on this subject I think we are practically of the same opinion. I have no doubt whatever that what I call contact forces are due to chemical affinities, and might therefore be called chemical stresses; but I have called them contact forces, because they can only be measured as contact differences of potential. The point I mainly wished to urge is that it is fallacious to argue that because a cell has a certain electromotive force it must have certain reactions inside it, because it would first have to be shown that in cells where the chemical action is known the electromotive force corresponds with the heats of combination. If in many cells whose chemical action is known the electromotive force does not correspond with the heats of combination, it cannot be assumed that they do in a lead secondary cell.

Another point is completely overlooked as a rule in discussing the theory of electrolysis; that is, that the heats of combination are not a measure of chemical affinity. Thus, there are many chemical actions in which the chemical affinities cause decompositions or reactions which actually absorb heat. These are known as endothermic reactions. It is quite possible—not to say probable—that the electromotive force corresponds accurately with the various chemical affinities, but we have no means yet of measuring these quantitatively. The electromotive force certainly does not correspond with the heats of combination. I quite agree with Mr. Williams as to the chemical stress in decomposing water with a peroxide anode and a zinc cathode, as I think it is a chemical stress; but until it is shown that it is, it seems safe to call it a contact force which merely localises the force without assuming any cause whatever.

As to the Dr. and Cr. reckonings, they simply amount to this:—"Put the heats of all the compounds decomposed on one side, and the heats of all those formed on the other, and take the difference." Sulphate of lead being formed on both plates is, of course, put twice on the credit side. It does not matter on which plate it is formed, the point is that it is formed and not decomposed. If it were formed on one spongy lead plate and decomposed on the other, it would cancel out. Thus in a Daniell cell the sulphate of copper is debited, because it is decomposed. If Mr. Williams were right in cancelling it out in a lead cell, he would have to add both the sulphates together, or give them both a negative value in a Daniell cell. If the sulphate of lead cancelled out, the heats of the other actions would give about four volts in the wrong direction!

I am afraid I shall never be in accord with Mr. FitzGerald. He says that Andrews got 42,282 as value of Zn,O, and got it from Miller's "Chemical Physics." Whether he has an old edition of Miller or whether he has a new one in which the corrections have not been made I do not know, but he is certainly working with a mixture of the old and new notations. The whole system was altered about 1870, I think, and Mr. FitzGerald does not take cognizance of this. Mr. FitzGerald is seventeen years behind the age in this point. If he is in the next century as regards his lithanode, however, nobody can complain. I do not want to insult him, but perhaps he is as bad a German scholar as I am, and has been reading Thomsen, which will be an excuse for any number of errors. The chief difficulty in reading Thomsen has, however, at last been removed by the publication of the fourth volume, which, as usual in German four-volume novels, contains, arranged in index fashion, all the verbs deferred from the other three.

Mr. FitzGerald still insists that 46,245 calories give two volts for Pb, SO_4; this assumes either the old notation or that Pb and SO_4 are monad radicles. The value 156,110 for Pb, SO_4 is, I think, correct. It corresponds according to my calculation with just over three volts.

When Mr. Williams calls me a chemist I am at a loss to know whether he means a compliment or a covert insult. If he had called me a theorist, or a professor, I should have known.—Yours, &c., JAS. SWINBURNE.

FIRST USE OF THE NAME TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The statement you quote from Mr. Lockwood, that the earliest use of the word telephone occurs in 1845 in connection with the invention of a certain Capt. Taylor, and that although the earlier "experiments of Prof. Wheatstone are far more intimately connected with the modern developments of telephony than those of Capt. Taylor, the term does not appear to have suggested itself to Wheatstone," is certainly inaccurate; and as its publication in *The Electrician* might lead others into error, perhaps you will allow me to point out one evidence to the contray. In the life of Wheatstone in "Lives of the Electricians," the following quotation is given from a statement written by Prof. Wheatstone in 1840:—"When, in 1823, I made my important discovery that sounds of all kinds might be transmitted perfectly and powerfully through solid wires, and reproduced in distant places, I thought I had the most efficient and economical means of establishing telegraphic (or rather telephonic) communication between two remote points that could be thought of. My ideas respecting establishing a communication of this kind between London and Edinburgh you will find in the *Journal* of the Royal Institution for 1831."

The word telephone is surely of earlier date than 1840. As Wheatstone is accredited with having first used the word microphone in 1827, it is scarcely credible that he was then ignorant of the word telephone; but he was sparing in his use of new or technical words.—Yours, &c. J.

Brixton, April 18th, 1887.

[CORRESPONDENCE *continued on page 523.*]

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 513
The Practice of Dynamo Design. By Guy C. Fricker. (Continued) ... 518
Technical Criticism ... 519
Submarine Cables.—IV. ... 520
Wreck of the Telegraph Steamer "Volta" ... 521
Correspondence ... 521 & 523
STUDENTS AND THE SOCIETY OF TELEGRAPH-ENGINEERS .. 522
The Pfannkuche Commutator for Converting Continuous into Alternating Currents ... 523
Induction Coils Graphically Treated. By Gisbert Kapp. Illustrated. (Continued.) ... 524
Electric Locomotion. By A. Reckenzaun ... 526
The Migration of Ions and an Experimental Determination of Absolute Ionic Velocity. By Dr. Oliver Lodge (Illus.) 525
The Resistance of Faults in Submarine Cables. By A. E. Kennelly, M.S.T.E. (Concluded.) ... 530
Companies' Meetings—
United River Plate Telephone Company ... 532
Telephone Company of Ireland ... 533
Eastern Extension, Australasia, and China Telegraph Co ... 534
Indo-European Telegraph Co... 534
Reuter's Telegram Company ... 534
City Notes, &c. ... 534
Companies' Share List ... 534

STUDENTS AND THE SOCIETY OF TELEGRAPH-ENGINEERS.

In the early days of the above-named Society it was hoped that one of its functions would be to give lectures, and even technical instruction, to students who contemplated the career of electrical engineering. This idea has never been quite lost sight of, and the formation of the grade of "students" in the Society's roll of membership still testifies to the original intention of the Council who introduced it. Later on, propositions have been made from time to time with a view of creating here a nucleus for that larger scheme of State-aided scientific research which found enthusiastic advocates only a few years ago; but which appears to have been swallowed up, or at all events superseded, by the Civic endowments at FINSBURY and SOUTH KENSINGTON. State-aided science did not find many advocates outside the circle of science itself, but as aid was forthcoming from a different quarter for purposes which have been described as "kindred" to those just referred to, the representatives of science, like sensible business men as they are, have cheerfully transferred their advocacy and services to the more tangible of the two schemes—that is to say, to the scheme which, besides yielding the best practical results, attracts the greatest amount of pecuniary support.

But meanwhile the class of Students attaching themselves to the one Incorporated Society, representing the profession to which they aspired to belong, increased in numbers, and the time arrived when something had to be done for them on the lines of the original programme. Had it not been for the circumstances just adverted to probably this would have been arranged long ago. On the other hand, it may be argued that but for the formation of the scientific and technical colleges above mentioned the STUDENTS who have attached themselves to the SOCIETY of TELEGRAPH-ENGINEERS and ELECTRICIANS would not have been as numerous as they are. In reality they are not very strong in numbers, amounting in all to between 60 and 70. But all the more is the COUNCIL to be commended for the step they have just taken in connection with these junior members of their SOCIETY. In another column will be found the copy of a circular letter just addressed to the STUDENTS, informing them that fortnightly meetings will be held in the Society's Library, on Thursday evenings, alternately with the General Meetings of the Society, for the purpose of reading and discussing Students' papers, or discussing papers read before the Society itself, and questions of interest relating to Electrical Science. A Member of the Council or a Member of the Society will preside on these occasions, but in other respects the meetings will be exclusively for Students.

Thus it will be seen that a kind of subsidiary society will be formed within the parent Society, and, we are glad to notice, with all the privileges pertaining to the larger body. That Papers by Students will have to be submitted for the approval of the Council is a condition which may subsequently be found inexpedient to enforce, the Students' own Committee —or Council—being a sufficiently responsible body to settle this matter for themselves. But this is a mere detail, the important point being that such papers as are deemed worthy of the distinction will be published in the Society's *Journal*, and their authors eligible for the Premiums which are annually distributed by the Society for contributions of special merit. This is an excellent arrangement, and one which we feel sure will entirely accord with the intentions of the original founders of these Premiums, who probably designed them mainly for the encouragement of young men of promise. There has been occasionally, we should imagine, some difficulty in awarding such Premiums satisfactorily, a difficulty which the new opening for Students' papers will help to remove.

Perhaps we have understated the number of Students now on the books of the Society, the figures in the Annual Report last Christmas being singularly obscure as regards the then total strength of Members, Associates, and Students. But the number given in the list dated August, 1886, was for the last-named Class 61; and thirty-three fresh candidates were elected during the whole year—how many before and how many after the August list was published does not appear. But it is evident their numbers are increasing more rapidly than in former years. In 1883 there were about thirty Students, and two years later they had only risen to forty-four; whereas between 1885 and the present date they number approximately about seventy—possibly more. Almost certainly they will now be largely augmented through the action of the Society in providing the Students with a separate existence more adapted to their capacity and needs than are the meetings of the general body of members. The presence of young men, which is a notable and a healthy feature of those meetings, is at the same time rather dispiriting, for the papers read on these occasions and the discussions which follow are often far away above the heads of the Students present, who conscientiously sit through the business but cannot be supposed to profit by it very much. We may safely assume that they will be glad to educate themselves up to the higher level of the General Meetings by attendance at their own, where papers will be read which they can all understand and profit by.

Nor is the training in public speaking which such meetings will afford to be undervalued. For mere debating power we have no respect whatever; and a young man had far better

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keep silence for ever than exercise his gift of speech in mere smartness of retort or fluency of caustic rhetoric. But it is undoubtedly a fact that to be able to say exactly what you mean is an accomplishment not only in great demand nowadays, but is well nigh indispensable to every kind of professional life. And whether we entirely approve of it or not it is certainly the case that many, if not most, of the leading scientific men of this age are good speakers; some, indeed, remarkably good. Now speaking—by which we mean speaking in public—is like swimming, nobody can essay it for the first time without nervousness; and this can only be overcome by practice. With speaking, therefore, as with every other desirable accomplishment, every young man should have his chance. Happily, only the few will ever attain to great excellence; but it is possible for all so to discipline their nerves and faculties as to be able to state in appropriate words what it is pressingly needful they should say. The discussion of scientific papers among themselves by the STUDENTS of the SOCIETY OF TELEGRAPH-ENGINEERS will afford them this opportunity, and we are sure they will not be slow to avail themselves of it.

KENT'S AUTOMATIC SWITCH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Seeing in your issue of April 8th an illustration of Kent's automatic switch, and having devised a somewhat similar one a short time since, I venture to trouble you with a few remarks upon it. In the first place I would suggest the following alterations, which I think would be found improvements:—The armature or lever carrying the forks dipping into the mercury should not have any coil upon it, but should be a permanent magnet. Another upright coil should be provided on the further side of the pivot, and both the coils should be wound partly with fine wire and partly with thick wire for series, in such a way that when one was a N pole the other would be S (the two coils being in series with each other, or in parallel, as deemed most convenient; personally I should put the fine wire in series and the thick wire in parallel). The fine wire of these two coils, instead of being a shunt to the terminals of the dynamo, should be a shunt to the terminals of the switch itself. As illustrated, the instrument appears to me open to the objection that when the current is cut off the armature loses its polarity, and would therefore be again attracted to the upright magnet, and in this way would keep up a vibratory motion, alternately making and breaking contact. It has also the objection that the whole time the dynamo is running a certain portion of the current is wasted in the shunt, and that it is necessary to lead a third wire to the dynamo to supply the current to the shunt. With the above suggested modifications these difficulties do not arise.

As soon as the E.M.F. of dynamo falls below that of accumulators, the polarity of both the upright coils is reversed, and the lever is thrown up, and the main circuit broken; a small current still, however, flows through the fine coil, and by repelling one end and attracting the other of the magnet holds the lever up. Upon the dynamo starting again, or recovering its speed, the current reverses, and closes the main circuit, *thus short-circuiting the shunt coils*, which thus are only used during the time that the switch is open, and not during the time the dynamo is working properly. The waste of power in the switch is thus only that due to the resistance of the series coils, which may be made practically *nil*. There is no danger of the permanent magnet reversing its polarity, as it is always in proximity to a pole strengthening it when the dynamo is working. It can be placed anywhere on the circuit between the dynamo and the accumulator, as there is no necessity for an independent wire to the other pole of the dynamo; and as the only force necessary to be overcome to change the switch from open to shut is that necessary to overcome the friction of the pivots, it can be set to open and shut almost absolutely at zero, thus causing a very minute spark at the mercury contacts. There is also the advantage that it requires no adjustment for any particular E.M.F. An instrument made thus may be taken off a 100-volt circuit, and put on to a 50-volt one without any alteration whatever; and as the current only passes through the fine coils for a short time, they may be much shorter than if a permanent current be kept up through them. I have had an instrument on these lines at work on an installation for several months, being led to devise it and put it on by frequent reversals, owing to the fact that I employ the engine in sawing wood and charging batteries at the same time. The engine is frequently pulled up by a heavy log being jammed against the saw, and as my dynamo is a compound one this gave much trouble, until I put this switch on, since which time (now several months ago) I have had no trouble whatever with it, as it breaks circuit the moment the dynamo slackens up, and starts on again directly the dynamo acquires its proper speed again. I trust you may think these remarks worth insertion.—Yours, &c., R. H. C. NEVILE.

Wellingore Hall, Grantham, April 13th.

P.S. I find the capacity of this switch to adapt itself to varying E.M.F. of great value in my case, where I am frequently charging different numbers of cells, and therefore requiring differing E.M.F.'s. I may perhaps mention that my engine is controlled by Richardson's electric governor, which I use both for ordinary electric lighting and also when the engine is charging batteries and sawing at the same time, and find it gives me every satisfaction.

THE PFANNKUCHE COMMUTATOR FOR CONVERTING CONTINUOUS INTO ALTERNATING CURRENTS.

An ideal system of distributing electrical energy should combine the advantages of continuous with those of alternating currents; that is to say, it must be equally serviceable for arc and incandescent lighting, for motors, and for charging secondary batteries, while at the same time it must admit of economical distribution over wide distances, with perfect independence in all parts of the circuit. For these reasons it has for some time been recognised that a device either for converting continuous into alternating currents at will in any part of the circuit, or for effecting the contrary operation, would, if sufficiently simple and economical in action, prove of great practical value. It is obvious that for either of these conversions we require a sparkless commutator. If this can be devised, it only remains to see that the losses in conversion are reduced to a minimum. Experiments have already been conducted in this country with a view to the utilisation of transformers for charging secondary batteries, but little or no success has hitherto been attained. We now read in the American journals that the converse problem, that of the conversion of continuous into alternating currents, has received a practical solution by the invention of a sparkless commutator due to Mr. A. Pfannkuche. The commutator is easily described; in principle it consists of a pair of brushes resting upon an ordinary split-cylinder two-part commutator, there are also two supplementary brushes which are set so as to have a lead over the main brushes equal to the width of the insulation pieces, so that the main circuit is never entirely broken. To prevent the short-circuiting of the dynamo when the supplementary brush is in connection with the opposite part of the commutator to that on which the main brush bears, each pair of brushes are connected through a resistance equal to that of the external circuit. It is, however, evident that this arrangement determines a loss in the conversion which may be represented by the ratio of the space occupied by the insulation to that occupied by the contacts of the commutator. Mr. Pfannkuche proposes to obviate this objection by making the resistance between the two brushes to take the form of the primary of a transformer, and using the secondary circuit to light a few lamps in the immediate neighbourhood. But this system, at best, can scarcely be offered as a complete solution, for so long as it is necessary to supply mechanical power to twirl the commutator, its use is

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practically restricted to the machine room (where it can be mounted on the armature shaft). In this case it is difficult to see what is gained by the system over the employment of an alternating current dynamo in the first instance. We may add that it is by no means clear that a commutator such as described will necessarily be entitled to the term "sparkless." The external circuit is entirely broken at every revolution, and if it contains much self-induction it is clear that a spark will follow the brush.

INDUCTION COILS GRAPHICALLY TREATED.*

BY GISBERT KAPP.

(Continued from page 504.)

A. *Disregarding the Saturation Term*—The formula for the impressed E.M.F. is capable of graphic representation. Starting with a given maximum current, I, we find the corresponding total induction and the values E_t and E_ρ by calculation, the resistance of the coil, number of turns and configuration of the core being supposed to be given. In the diagram (Fig. 1) O E the maximum impressed E.M.F., and the lag ϕ are found graphically from the known values of E_t and E_ρ by constructing the triangle O F_ρ E. The current at any moment is proportional to the projection of either OE_t or OE_ρ on the vertical O Y, and the impressed E.M.F. is proportional to the corresponding projection of O E on the vertical; both these quantities can by suitably choosing the scale be read directly off the diagram. The variations in the impressed E.M.F. and in the resultant current strength are thus represented by the variations which the projections of the two lines O E and O E_ρ undergo whilst these lines are revolving round the centre O, the former being always in advance by the angle ϕ. In other words, the current lags behind the impressed E.M.F. by an interval of time represented by this angle. It is evident that the lag is independent of the impressed E.M.F., but increases if the resistance is decreased. Assume now that the condition of the apparatus represented by the diagram is well within the limits for which direct proportionality between magnetising force and total induction can be assumed, then an increase or decrease of impressed E.M.F. will produce a corresponding increase or decrease of E_t, E_ρ, and I, without alteration in the angle of lag. If the resistance r be diminished, the current will increase, and *vice versa*. This can easily be seen from the diagram. Let O E_ρ''/O E_ρ represent the ratio in which the resistance has been diminished, and assume for a moment that the current has not altered. This could be attained by a suitable reduction of impressed E.M.F. from O E to O E′. The new angle of lag is now ϕ'. But if the impressed E.M.F. has not been reduced, all the quantities must be increased in the ratio O E/O E′, and we find OE_t' and OE_ρ' as the true values of E.M.F.'s due respectively to induction and resistance. If the scale for the current has been so chosen that O E_t represented the current before the reduction in resistance took place, the length O E_t' gives at once the new current, and it will be seen that even were it possible to reduce the resistance to zero, the current could not exceed the value O E. The case here considered is of importance when arranging arc or glow lamps in parallel between a pair of mains fed from an alternate current machine. In this case, a coil having self-induction (termed by Mr. Gordon, who originated this system, a "choking coil") is placed in each lamp circuit. The resistance r consists, then, of two parts, that of the lamp, which we may regard as free from self-induction, and that of the coil, which has a considerable self-induction. The resistance of the coil is, however, comparatively low, so that there is a very large difference in the resistance of each branch when the lamp is properly burning, and when, by design or accident, it is short-circuited. Notwithstanding this great difference, the current passing in the latter case need not be very much larger than the normal current, and since its angle of lag is nearly 90°, the waste of energy is only trifling. A simple calculation, which need not here be given, shows that if hysteresis be neglected, the waste of energy is only due to the resistance of the choking coil, which, of course, can be made very small.

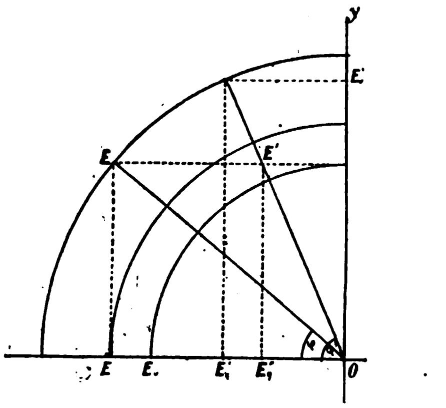

FIG. 1.

B. *Taking the Saturation Term into Account.*—Only a slight modification of Fig. 1 is required to obtain an approximate solution of the problem in the case that the iron core of the coil is so small as to become saturated. In that diagram, O E is a line drawn under such an angle ϕ to the horizontal, that its projection on the vertical may be considered to graphically represent to a suitable scale the total induction, whilst its projection on the horizontal may similarly be considered to represent the magnetising force. In fact, we may consider O E to be that portion of the characteristic of magnetisation which, on account of its proximity to the origin, is a straight line. In Fig. 2, this characteristic, shown dotted, is prolonged. If saturation did not intervene the current would, to a suitable scale, be represented by the length E E_t, and the E.M.F. of induction by the length O E_t, the angle of lag being ϕ. But since, on account of increased magnetic resistance with approaching saturation, the current does not produce the full induction, the E.M.F. of induction must be smaller than O E_t. If the magnetic resistance were constantly maintained at its increased value, the intersection E′ of the circle representing the impressed E.M.F. with the characteristic would give the point the projections of which represent, as before, current and induced E.M.F. On this supposition, the angle of lag would be ϕ', the current would be E′ E_t' (measured with the same scale as previously), and the induced E.M.F. would be O E_t'. The current now found is evidently larger than E E_t. But the magnetic resistance is not constant; it has its initial or minimum value at the moment when the induction and current pass through zero, and it has a maximum value when the induction and current are maxima. If we construct the diagram on the assumption of constant minimum magnetic resistance, we obtain the current E E_t, which is evidently too small, whilst the angle of lag is too large; if we assume constant maximum magnetic resistance, we obtain the current E′ E_t', which is evidently too large, whilst the angle of lag ϕ' is

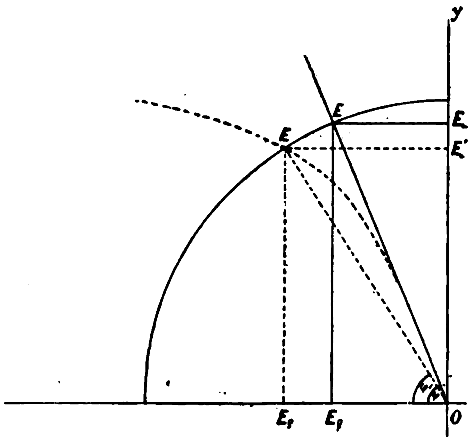

FIG. 2.

* From *Industries*, April 15, 1887.

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too small. The true values lie somewhere between the points E and E[1], probably nearer the latter, because hysteresis, which has been neglected, must operate in the same direction as an increase of magnetic resistance, and is of greatest influence at those moments when the magnetic resistance is a minimum. As an approximation sufficient for most practical purposes, $E'E_t'$ can be taken as the true value of the current.

It will be seen that an increase of impressed E.M.F. as soon as the knee of the characteristic has been passed, results in a comparatively large increase of current. In other words, the choking power of the coil begins to break down after this point, and under increasing pressures its action approaches that of a resistance without self-induction.

(To be continued.)

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the late meeting of the British Association on various subjects connected with Electrolysis :—

ON THE MIGRATION OF IONS AND AN EXPERIMENTAL DETERMINATION OF ABSOLUTE IONIC VELOCITY.

(Continued from page 509.)

BY DR. OLIVER LODGE.

Direct Experimental Determination of Absolute Ionic Velocities.

Let us pass now from this rather laborious method of determining N_1u_1, N_1v_1, &c., to a simple and direct mode of experimenting on the velocities u_1 v_1 themselves. It is manifest that if one can determine for any substance Nu by one method of experiment, and u by another, its dissociation-ratio N/m, which must be a very important chemical constant, is known instantly.

One of the early forms of experiment for observing u and v was arranged thus :—

Two vessels, containing fairly strong sulphate of soda and baric chloride, respectively, adjusted to equal density, were joined by a longish tube full of dilute hydrochloric acid of small specific gravity (Fig. 2).

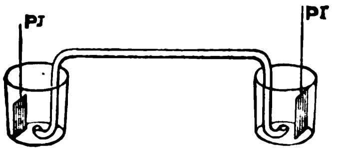

Fig. 2.

A current from some twenty storage batteries was then applied, and the tube examined from time to time for the first appearance of a precipitate of baric sulphate.

When everything went well the precipitate appeared as a fine ring inside the tube, which rapidly filled up into a beautifully sharp thin disc or complete partition, and then grew in thickness, spreading out slowly both ways till it formed a solid plug and rather obstructed the current.

The locality of the disc and the time of its appearance after starting the current were noted, but I do not here record these first results because they were very variable, owing to disturbing causes.

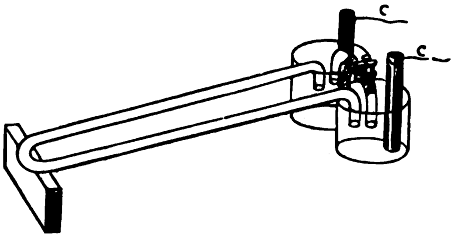

Fig. 3.

One obvious disturbing cause is that of slight differences of level, produced either by earth warpings and local pressures, or by evaporation. To diminish mechanical changes of level the two vessels were next arranged side by side, and the tube was bent double so as to have its ends close together and yet to afford a good length for observation.

The level of the vessels was accurately adjusted, and the tube introduced with as little disturbance as possible, various devices, such as supernumerary tubes and stopcocks, being sometimes employed to assist this (Fig. 3).

To diminish evaporation a layer of paraffin was sometimes put on each vessel, and my assistant, Mr. Robinson, hit on the happy device of connecting the two layers of paraffin by another and a much shorter and stouter siphon tube full of paraffin, so as to equalise the levels and, if possible, to keep them equal, and yet not to tap off any of the current by this supernumerary but also infinitely resisting path (Fig. 4).

We now got much more consistent results, and for a long time thought things were pretty satisfactory, so we proceeded to make numerous observations, varying the character and length of the tubes, the number of volts applied, the strength of the solution, &c.

The difficulty of electric endosmose is an obvious one, and it may be owing to this that the results of these experiments are not very concordant. Omitting minor corrections, however, and taking the measured ratio of the distances of the ring precipitate, from the $BaCl_2$ vessel end, and from the Na_2SO_4 vessel end of the tube, for all those experiments where a paraffin levelling tube was used, we get the average result that the ring forms 3·2 times as far from the $BaCl_2$ end as from the Na_2SO_4 end.

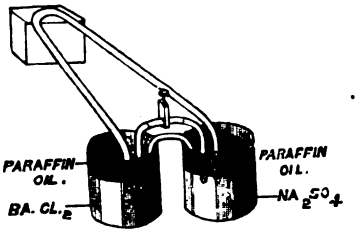

Fig. 4.

This may be recorded by saying that the Ba travels three times the distance that the SO_4 travels in the same time, or that Ba travels three times as quick as SO_4; a result which, though simple and definite, is probably incorrect. But it is possible to argue that what we are measuring is not this simple ratio of speeds but a more complex ratio depending on all the substances. Thus consider the substances in action

$$Na_2\ SO_4 \mid HCl\ HCl\ HCl \mid Ba\ Cl_2$$

and pass the current from right to left.

On Hittorfian principles, H travels to meet the SO_4, and journeys the greater part of the distance between them ; Cl also travels to meet the Ba. Call the true velocities of these four ions, h, s, c, b respectively ; then the position of the precipitate of the meeting Ba and SO_4 may be thought to really measure, not $b : s$, but

$$\frac{b}{c} : \frac{s}{h}.$$

Now, on Kohlrausch's calculation, $h = 29$, $b = 3·3$, $c = 5·3$, s is not certain, but from Hittorf we may take it as roughly equal to the velocity of K viz., 5·1 ; in which case

$$\frac{bh}{cs} = \frac{3·3 \times 29}{5·3 \times 5·1} = 3·5.$$

I by no means press this probably accidental agreement ; and the true meaning of any results obtained by such methods as I have described I leave for the present open.

On my cursorily mentioning these very preliminary results in a circular to the committee on Electrolysis, Prof. S. P. Thompson suggested using a jelly, and we at once tried it. One cannot use any strong acid with gelatine, for it seems to spoil it, but acetic acid serves ; and the siphon tube was accordingly filled with an acetic acid gelatine jelly, which went stiff when cold. Agar Agar jelly can be used with stronger acids.

The use of jelly makes the experiment much less troublesome, because there is now no difficulty in the manipulation, no special need for adjustment of the solution densities, nor danger from changes of level.

One objection to it is that, supposing the ionic velocities were determined in jelly, they could not easily be compared with Kohlrausch's numbers, which apply to weak aqueous solutions. There is of course no difficulty in determining the conductivity of the jelly or the slope of potential, as required in formula (1) ; but it is difficult to assign a value to N. The hypothesis that the solvent does none of the conduction, even though it be true for water, can hardly be pressed to include the case of a jelly of unknown and complicated constitution ; especially as we found that the conductivity of plain jelly was actually considerably greater than that of dilute acetic acid.

The endosmose difficulty is not got over by the use of jelly—in fact, it may perhaps be accentuated ; and another and unexpected difficulty presents itself. The jelly swells under the action of the current and exudes from the tube ; but always in one direction only, viz., against the current. A cylinder of jelly an inch or two in length was ultimately protruded from the anode end of the tube ; and cracks appeared in the substance of the jelly of a curious serpentine form which underwent noteworthy metamorphoses.

The position of the precipitate in these jelly tubes was not far from the middle of the tube, indicating that Ba and SO_4 travelled at nearly equal rates.

Second Series of Experiments.

I next proceeded to another form of the experiment, where a detecting substance was placed in the tube so as to be able to follow the motion of the ions along their journey, instead of only noting their time and place of meeting.

Various detectors were tried, but a simple and obvious one, able to show both anion and cation, is sulphate of silver.

A jelly tube containing, besides acetic acid, a solution of sulphate of silver, was arranged to join two vessels, each full of baric chloride solution. When the current passes, the barium travels with it and causes a precipitate of $BaSO_4$, which may be watched creeping on from point to

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point; the Cl at the same time travels against the current and causes a precipitate of Ag Cl, which may be likewise watched. The poor solubility of Ag_2SO_4 is of no consequence, because it is only wanted to *detect* the ions, not to absorb them and stop their motion; hence, however soluble a detector was used, the amount of it put into the tube ought to be almost infinitesimal, or it will cause disturbance and prevent the full velocity of the ion being observed.

There is some slight difficulty with a solid precipitate when free liquid instead of jelly is employed, for its settling causes currents and convulsive disturbances—especially in the vertical ends of the tube. Fluid detectors, whose colour the ions change, are therefore in some respects better.

Roughly examining the results obtained by the methods just described, one may say that they give the velocity of Ba through jelly, for a fall of 1 volt per centimetre, as about ·00012 centimetre per second; the velocity of Sr is about ·00015. The speeds of Cl, Br, and I are not very different from each other, and about ·00024. This rough statement is merely to give a notion of the order of magnitude of the velocities obtained, and by no means represents the full deduction from the tabulated numbers.

Experiments on Speed of Hydrogen and Hydroxyl.

To detect the motion of *Hydrogen* Mr. Robinson devised the following arrangement:—We happened to have been using phenol-phthallein as a detector of alkali in some other quite distinct experiment, and so it was a handy substance. The jelly tube contains a little phenol-phthallein and a trace of common salt, just made alkaline enough with soda to bring out the colour. The solution in anode vessel is H_2SO_4; in cathode vessel the same, or sometimes $CuSO_4$.

The result is that SO_4 travels one way, and H_2 the other. As the H travels it liberates HCl, and decolorises the solution. As the SO_4 travels it also decolorises the solution by forming neutral Na_2SO_4. The velocity of hydrogen, for 40 volts applied to a 40 centimetre tube, came out from the very first observation thus made

·0029

centimetre per second. Kohlrausch's theoretical number, deduced from conductivity and migration data, is

·003.

Later experiments gave respectively ·0026 and ·0024. SO_4 seems to travel at about one-third this speed.

Another experiment can be made with NaHO in cathode vessel, and $CuSO_4$ in anode; and then with NaCl and phenol-phthallein in the tube, as before, but colourless. HO now travels against the current and produces colour as it goes. It seems to travel nearly as quickly as hydrogen.

(To be continued.)

ELECTRIC LOCOMOTION.*

BY A. RECKENZAUN.

No less than seven papers bearing upon the subject of the transmission of power by means of electricity have been read and discussed in this room within the last six years, Mr. Alexander Siemens, in 1881, taking the lead with an interesting address on "Electric Railways and the Transmission of Power by Electricity." This gentleman again favoured us in April, 1883, with an account of the great progress made during an interval of two years by Messrs. Siemens on the Continent, and he was followed at the same meeting by Dr. Edward Hopkinson, who presented an equally interesting communication on "The Portrush Electrical Railway." A few weeks later, Prof. George Forbes enlightened us with his most instructive lecture, entitled "Electricity as a Motive Power." The late Prof. Fleeming Jenkin described, in 1884, an ingenious system of electric haulage called "Telpherage." During the same session, I made an attempt to explain the principle of applying electricity to the propulsion of "electric launches;" and last year, on the 22nd of January, Captain Douglas Galton, in his excellent paper on the "Results of Experiments on Mechanical Motors for Tramways at the Antwerp Exhibition," presented us with most valuable data concerning mechanical traction. Yet, with all this vast amount of useful information before me, I have had little difficulty in selecting a point of view from which we may regard the subject to-night. The ground has been so well prepared on the various occasions enumerated, that there is now no necessity on my part to explain the principles involved in generating electricity, and transmitting or converting the same for the purposes of electric locomotion. I therefore beg to offer the following observations as an appendix to the afore-mentioned papers, and to bring forward fragmentery descriptions of details of construction, also, where possible, working expenses and the amount of traffic on several electric tramways in this country and on the continent of Europe.

Experiments with electric motors and their application to purposes of locomotion date as far back as 1834, when Prof. Jacobi first investigated the principles involved. The history of these early attempts, as well as the work of subsequent inventors who helped to develop the idea of Jacobi, Paccinotti, and others, up to the present day, would prove far more interesting than the present essay; but I trust that the facts and figures of this paper will in some measure compensate for omissions concerning historical data. It has become the custom to distinguish between different systems of electric tramways, by the methods adopted in conveying the energy generated in the stationary dynamo to the electro-motor which moves along with the car, and we may divide these systems as follows:—

1. The system in which the ordinary rails serve as conductors of the electric current, the axles of the car being insulated from the wheel tyres, and circuit with the motor established through a contact brush, or roller, sliding along the rails.

2. The system of overhead conductors. In this a number of strong posts are placed alongside the line, carrying slotted tubes or rods of metal, upon which sliding or rolling contact-carriages are placed, and these communicate electrically with the car-motor by means of a flexible cable.

3. The system of the "third-rail conductor," which is placed between the ordinary rails, or alongside the line, on insulators a short distance above ground.

4. The system of underground conductors enclosed in a channel, with a central slot for the free passage of the contact-carriage.

5. The system of well insulated underground conductors, with no channel, temporary contact being made through short sections of surface contact-rails with the motor on the car during its passage over that particular section on which the car is moving at the time.

6. The system of applying secondary batteries within the car, carrying stored energy along with it, whereby the vehicle is rendered independent, so that it can run on any line of suitable gauge without alteration to the roadway.

7. The system of applying secondary batteries to a separate locomotive, which hauls an ordinary car or cars behind it.

Members of the Society of Arts, and readers of the technical journals, will recollect that on the 12th of May, 1881, an electric tramway between Lichterfeld Station of the Berlin-Anhalt Railway and the Central Military School, a distance of one and a-half mile, was opened to the public. Not many weeks ago I visited that district near Berlin in order to obtain some information concerning the working of the tramway, and I have the satisfaction of telling you that the electric cars, although in continuous operation for a period of six years, have exhibited no signs of deterioration, and there have been no mishaps worth mentioning. The rails, which serve as conductors, are laid along the high road principally, and a small portion of the line runs across fields. No special means of insulation were used, the rails being fixed in the ordinary way to wooden sleepers, laid transversely along one side of the road. Electrical contact between sections of rails is effected through flexible copper loops. With such short lines of comparatively little resistance, the electromotive force can be kept low, and, in the case of the Lichterfeld line, it amounts to only 90 or 100 volts, and is therefore not dangerous to the touch of man or beast. Several roads cross this line, and at such crossing places the rails are cut out of circuit by means of underground cables; contact boxes, with switches, are placed near the crossings, in order that the current may be sent through these insulated sections of rails if requisite. The house containing the steam engines and generating dynamos is situated close to the rails, but at a distance of about one-third of a mile from the Lichterfeld terminus. There are two steam engines, each of 6 horse-power nominal, and two Siemens dynamos; one is a horizontal engine, and this is generally in use when one car only is running; and the other is a Dolgourouki high-speed rotary engine, coupled direct to the dynamo, running at 700 revolutions per minute; this latter comes into requisition when the traffic demands the second car. According to the printed time table, one car makes 24 journeys a day, between 7:47 a.m. and 11:21 p.m.

I have not been able to ascertain the working cost of this line, but it must be very low, since the engines and dynamos are in the house, which also contains the pumping machinery of the district waterworks; one engineer and one stoker attend to both the hydraulic and the electric apparatus, the same boiler serving both purposes, and these men find time to attend to minor repairs. On the car is a driver, but no conductor. Each vehicle carries twenty-four passengers; it weighs, when empty, but including motors and gearing, 3·2 tons. The average speed is twelve miles an hour, and one journey occupies nearly eight minutes, for which a passenger has to pay 20 pfennige. This is nearly 2½d. About 100,000 passengers are carried annually. One remarkable fact in connection with this successful enterprise is that the cars, although identical in every other respect, are fitted with different kinds of gearing, with a view of ascertaining practically the efficiency of each. Those who have devoted their attention to the subject of electric locomotion are well aware that the choice of the mechanical transmission between the fast running motors and the comparatively slow motion of car wheels is one of considerable difficulty. To the uninitiated it seems the easiest thing in the world to reduce, for instance, 800 revolutions of one shaft to 80 revolutions of another shaft; but when the arrangement has to be applied to a tram-car, where space is limited, noise objectionable, dirt and dust in abundance, then one obstacle after another seems to appear. This branch of our subject really deserves a separate and exhaustive treatment, if we had sufficient time at our disposal; but as I have chosen such a sweeping title, I shall have to confine my remarks on mechanical gearing within very narrow limits. With regard to the Lichterfeld cars, the one which ran some 13,000 miles per annum, or nearly 76,000 miles since the opening of the line, is fitted with a peculiar kind of transmission, little known in this country. The motor, in this case is fixed underneath the floor, in the middle of the car, with the shaft of the armature parallel to the axles. The motor shaft carries a pulley of small diameter with 27 V-grooves cut upon its rim; one of the car axles has a large pulley with 13 grooves, and the other car axle carries a similar pulley upon which 14 V-grooves are cut. The wheel-base is 5ft 9in, consequently the centres of the pulleys are only 2ft. 10½in. apart. Within the grooves run 27 cords of spiral steel wires, so that one driving axle is worked by 13 and the other by 14 cords from one common pulley on the motor. The steel cords are made of a pair of wires wound closely upon a mandrel rather less than one-eighth of an inch in diameter; the mandrel is afterwards withdrawn, so that a stiff and yet flexible spiral is left with an external diameter of barely $\frac{3}{16}$ of an inch. The ends of each spiral cord have steel eyes screwed into them and soldered, and when placed in position these eyes are connected by a steel wire link. One curious fact about these spirals is that they stretch very little, and experiments have shown that one single cord will suffice to draw the empty car on a clean level line, whilst 8 cords were used for a car full

* Paper read before the Society of Arts on Wednesday, April 20th, 1887.

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of passengers; therefore, with 27 there is a good margin of safety. As may be expected, this mechanical arrangement works without noise or vibration. Some experience is required in putting the cords upon the pulleys, for, I am told, if stretched too tightly, they are liable to break at the joints, and if too loose they will slip when starting; but with careful attention on the part of the engineer in charge very few breakages occur. There are only moderate gradients on this line, the worst one of 1 in 100 is about 460 yards in length; the question, therefore, remains whether this kind of gearing would suit a more difficult line. The second spare car belonging to this tramway is fitted with pitch-chain gearing; as in the former case, the motor is placed centrally underneath the floor, with its shaft parallel to the car axle, but only one of the pair of axles is connected by means of the chain to the toothed wheel of the armature. There is some noise and vibration with this arrangement, more current is required, and slightly less speed is obtained with this vehicle than with the other; consequently, chain-gearing must be less efficient than steel cords, the motors and all other conditions being similar.

Another line on which the ordinary rails serve as conductors of the electric current is that of Mr. Magnus Volk, at Brighton. When opened by the Mayor of Brighton, on August 2nd, 1883, it was only a quarter of a mile long, running from the Aquarium to the Chain Pier; 30,000 passengers having used it during the first five months of its existence, Mr. Volk obtained permission to extend it as far as Kemp Town, a distance of nearly a mile from the Aquarium. The rails are fastened to wooden sleepers which rest upon the shingle along the beach, and no special insulation is employed; the necessity of passing under the Chain Pier involved a gradient of 1 in 28 on the west side and 1 in 14 on the east side of the pier. Two cars connected together, and containing 60 passengers, mount these inclines without difficulty. Each car, when empty, weighs 1¼ ton, and with 30 passengers about 3¼ tons; the speed is limited to eight miles an hour. The motive power in this case is a 12 horse-power gas engine placed at one end of the line, driving a Siemens compound dynamo, which generates a current of about 20 amperes at 160 volts when one car is running. As a rule, only one car is used, but on bank holidays and special occasions, when the traffic is great, the second car is put upon the line. The average distance made by each car last year, I am told, was 23,475 miles, and the expenses per car mile amounted to only 2d. This is remarkably low, considering that gas is used in the prime mover, costing 3s. 3d. per 1,000 cubic feet, and this item alone amounted to 1·11d. per mile; for wages ·7 of a penny was expended; oil, waste, &c., ·07 of a penny, and the repairs to machinery came to ·12 of a penny per car mile. The number of passengers last year averaged 8 51 per car mile, and the total expenses amounted to 55 per cent. of the gross receipts. On the Brighton cars leather link belts are employed for transmitting the power of the motor to the driving axle; the armature shaft is provided with a 5in. pulley; this gears into a 24in. pulley, on a countershaft fixed under the car. Mr. Volk used plain leather straps at first, but found them unsatisfactory, whilst the linkbelts proved quite practical, after an experience reaching over a period of nearly three years. A sample of a worn-out belt of this description has been sent by Mr Volk. The belts slip a little at starting, but this is not considered a disadvantage, since it eases the motor; the bearings of the countershaft are adjustable by means of a slide, so that any slack caused by stretching of belts may be readily taken up. No protection is provided for the gearing, there being no mud to contend with, but I fear that this arrangement would hardly be suitable for the ordinary street cars. Judging by the large traffic which the Brighton line enjoys, one would think that it is highly popular; it is so with the public, but a section of the town council is opposed to the enterprise. The line was severely damaged by storms in September, 1883, December, 1884, and October, 1886, involving a large outlay for repairs, to the anything but "permanent way." That it is a success in every way, excepting the storms from within the Town Council, and storms from across the sea, may also be gathered from the fact that a million passengers have already been carried, without injury or mishap to one of them.

Coming now to lines worked by means of overhead conductors, on the plan of Messrs. Siemens and Halske, the most carefully constructed, if not the most important, is that of Mœdling, near Vienna. This is the property of the Austrian Southern Railway; the rails wind through a lovely country district for a distance of 2 8 miles, and terminate in that beautiful spot with the ugly name—Hinterbruehl. I am indebted to Mr. C. Jenny, engineer of the Southern Railway, and to Dr. Dolinar, electrician of the Mœdling tramway, for their extreme courtesy in conducting me over the line and stations, and for allowing me to inspect every detail concerning the working of the same. Like most of the existing electric tramways, this has a large traffic during the summer months, but a comparatively small one in winter. The number of passengers carried during the year 1886 was 342,257; of these 320,000 came between the 1st of April and the 31st of October, whilst in the five remaining months only 22,257 persons availed themselves of this mode of transit. The month of August, with 72,600 travellers, stands highest in the list, and January, with 2,557 passengers, stands lowest of all. The revenue of seven months of the milder seasons is fifteen times as great as the revenue of the remaining five months, but the working expenses were not at all proportional, barely as five to one, and with all that the average cost did not amount to 3½d. per car per mile, inclusive of every item of expenditure, the sum of which came to £1,700 for the year ending December 31st, 1886. The number of car miles was 91,002, with a consumption of 545 tons of coal, at 7s. 6d. the ton. This was a very inferior "brown coal," with an evaporative power of barely one-half that obtained with anthracite. The cost of fuel, therefore, came to ·54 of a penny per mile, representing a consumption of 13 4lb. per car mile. With coal of the best quality, 7lb. per mile would suffice, but the price of this in Vienna is more than double that of "brown coal."

The generating station is situated at the Mœdling terminus; it contains three portable engines of 12 horse-power (nominal) each, and six Siemens compound dynamos, each capable of producing 500 volts and 30 amperes. When two loaded cars are running, *i.e.*, one electric car, to which an ordinary car is attached, the indicated power of one engine varies between 12 and 20 horse-power, according to the position of the vehicles relatively to the line during the outward journey. The track consists almost entirely of curves, with radii of from 60 feet and upwards. Moreover, the terminus of Hinterbruehl lies 120 feet higher than that of Mœdling; thus the line consists of a series of gradients, so that for the outward journey a considerable amount of attractive power is necessary, whilst on the return journey the cars run almost entirely by the force of gravity, and the driver touches the switch only when starting and at the sharpest curves. During the winter months one electric car suffices, and then one engine and one dynamo are used, attended by an engine driver and a stoker. In summer, when three engines, six dynamos, and six double cars are running, three stokers are required. The maximum number of journeys each of 2·8 miles, last summer was 180 a day, with six electric and six ordinary cars coupled in pairs, and the minimum number of journeys in winter with one car was 24 per day; the time allowed for one journey is 20 minutes. There are four stopping places along the line, and the average speed allowed is 9½ miles an hour. The conductors—the metal ones, not the animate being of the car—are carried on posts 18ft. high and 90ft. apart, except on sharp curves, where they stand at a distance of 45ft. from each other. These conductors are made of slotted tubes, in lengths of 15ft. each, and soldered together when placed in position. To prevent them from sagging, stout wires are stretched over brackets on the tops of the posts, and fastened to the tubes half way between the posts. The bore has to be made perfectly smooth and clean, so that neither mechanical nor electrical resistance is offered to the contact carriage sliding within. The actual diameters of the tube are 1in. internally and 1⅝in. externally. The contact carriage consists of a flexible piece of flat steel, upon which three gun-metal pistons are fastened. These pistons, which have to be renewed every two months, are made in two halves, with springs in the middle, whereby a slight pressure is produced between the surfaces in contact. The resistance of the conductors is two ohms, and the insulation in damp weather never falls below 6,000 ohms. Measurements gave a difference of potential of 500 volts at the dynamo, and 390 volts at the furthest end of the line when three electric cars were running, and this would correspond to a current of about 18 amperes per car. All the electric cars on this tramway are fitted with spur-gearing; but I will reserve any remarks on this mode of transmission until I am describing another line worked on the same principle. The Mœdling-Hinterbruehl Tramway has been working successfully since 1884, at an average cost of 3·42d. per car mile, inclusive of every item of expense.

The second line, almost identical with the last one, as far as electrical details are concerned, is that of Frankfort-on-Main, in Germany. It leads from the "Roemerbrucke," in Frankfort, through the villages of Sachsenhausen, Oberrad, and through the town of Offenbach; its total length is 4·1 miles; it has a double track laid with ordinary tram rails, thus differing in this respect from the Mœdling line, which has a single track with three passing places, and ordinary railway rails of a light construction. Single cars, as well as trains composed of one electric and one ordinary car, run between Frankfort and Offenbach every twenty minutes, from six in the morning until eleven o'clock at night. The entire rolling stock consists of fourteen vehicles, ten of which are fitted with electric motors. All are constructed to carry twenty-four passengers; but the weight of the electric cars is four tons empty, and that of the others about two and a-half tons. The engine house is situated at Oberrad, nearly half way between the termini. It contains two horizontal steam engines of 120 horse-power each, and four vertical Siemens dynamos, each capable of generating a current of 70 amperes and 300 volts. Ordinarily on week days four pairs of cars are running, when one engine, working at half power, is used for driving two dynamos. With eight electric cars and four ordinary cars on the road, the engines indicated 164 horse-power. The average speed allowed on this line is seven and a half miles an hour, and one journey occupies forty minutes, inclusive of stoppages at eight stations.

The Frankfurt Offenbach Tramway has been in operation since April, 1884; last year, 990,238 passengers were conveyed, and 292,269 car miles were run, at a cost of 3·83 pence per mile, including the following items:—

Wages and salaries of directors, clerks, &c.	2·23d.
Fuel (7·54lb. of coal per mile)	·65d.
Oil, waste, &c.	·13d.
Repairs of machinery, cars, and permanent way	·82d.

If we could deduct the directors' fees, repairs to roadway, and such items, which do not really belong to the costs of motive power and maintenance of the same, then the expenses per car mile might come to less than 3·5d. With reference to the overhead conductor, I need only mention that the slotted tube is used in the same manner as at Mœdling, with the exception that its resistance in the present case is only 1·6 ohm, and the contact carriage is somewhat differently constructed, as will be seen in the second diagram. Instead of three gunmetal pistons made in halves, there are two solid iron pistons without expansion springs. These parts have to be renewed every three or four weeks, at the cost of 1s. for each carriage.

In this line there are several gradients, the stiffest of which is 1 in 32 for a distance of 100 yards; another of 1 in 45, 150 yards long, with a curve of 110 feet radius upon it; and a third incline of 1 in 80, 300 yards in length. To those who study the subject of mechanical traction, the following data relating to the tramway under discussion may be interesting. The energy expended was measured on the car as well as on the generating dynamo, simultaneously, when the total weight, propelled at the normal speed, was 8·35 tons, comprising one electric car hauling an ordinary car and passengers:—

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	Electrical measurements. H.P. on car.	H.P. at dynamo.
Running on a level road	3·87	6·47
Running up gradient 1:45 without curve	8·00	13·5
Running up gradient 1:45 with curve...	9·70	16·7
Starting up gradient 1:150	10·2	26·4

I have already stated that spur gearing is used on the Mödling cars as well as on those of Frankfort; concerning the working of the latter I will now submit a few particulars. The train of wheels on one of these cars consists of a pinion on the motor shaft having 17 teeth which gears into a spur-wheel of 56 teeth keyed upon a countershaft. On this countershaft is the second pinion of 26 teeth, and this drives the spur-wheel of 52 teeth fixed to the car axle. We get thus a ratio of 1 to 6·6 nearly between the motor and the car wheels; the whole set of wheels weighs 4cwt.; the electric motor also is very heavy, so that the driving apparatus of one car comes to about 26½cwt. It must, however, be noted that the motor runs at the comparatively low speed of 500 revolutions. A considerable amount of noise is produced by this gearing, so that the sensation felt inside the electric car is anything but agreeable. As regards the economy of spur gearing for tramcars of this description, the experience gained is not at all favourable; the pinion of the motor, for instance, which is made of hard gunmetal, wears out in a month. One of the cars is now being fitted with wheels having double helical teeth, and it is expected that these will work more smoothly, and be more durable. I am indebted to Mr. Prins, the manager, and to Messrs. Dill and Strauss, of Frankfort, for their kindness in conducting me over the line and premises, and for affording me every facility in studying the whole arrangements. Overhead conductors of a different form to those just described were constructed by Messrs. Siemens and Halske for the electric railways in the mines of Zankerode, in Saxony, and the Hohenzollern Colliery, in Upper Silesia. The Zankerode line has been in operation since the autumn of 1882, and the Hohenzollern was started in August, 1883; another is now being constructed for the salt mines of Stassfurt. In all these, the conductors are made of bars in the shape of an inverted T fixed along the roofs of the mines. Sliding contact pieces grip the edges of the lower flanges of these bars, and insulated wires lead from the slides to the electrical switch on a small electric locomotive which hauls a number of trucks. An interesting description of the Zankerode line is given in Mr. F. I. Rowan's paper, recently read before the Mining Institute of Scotland.* Mr. Rowan states that the cost of haulage, including 15 per cent. for depreciation of plant, came to only ·77 of a penny per ton when 660 waggons were drawn per day of sixteen hours.

Concerning the Hohenzollern line, Mr. Zacharias, of Berlin, has kindly placed his notes, which contain many details of its construction and working, at my disposal; but unfortunately our time is limited, and I can therefore give very few particulars at present. Two sets of rails are laid underground, for a length of 820 yards, and there are several curves of from 15ft. to 30ft. radius. About forty trains run daily, with one locomotive and fifteen waggons. Each waggon carries nearly half a ton of material, and the cost of haulage is said to be about ½d. per ton. The steam engine and dynamo are placed near the top of the shaft, 250 yards above the working level; when running at 277 revolutions per minute, the generator gives 350 volts and 37 amperes. Each waggon weighs, when empty, 1,210lb., and when loaded, a littte over a ton. The electric locomotive weighs 2·1 tons, and the whole train of fifteen waggons 17·8 tons, running at an average speed of seven miles an hour. For transmitting the motion of the motor to the driving wheels, two pairs bevel wheels, one pinion, and two spur wheels are employed.

Among the lines on which the "third rail" system of conductors is used, the electric tramway of Portrush, and that of Bessbrook, both in Ireland, must be considered the most important. The Portrush line, which was described in this room four years ago, is the longest electric tramway in the world; its rails traverse the country a distance of six miles, between the terminus of the Belfast and Northern Counties Railway and Bushmills. Since the reading of Dr. E. Hopkinson's paper, important additions have been made by the installation of two 50 horse-power turbines, driven by a 26ft. waterfall on the river Bush, which is 1,600 yards away from the nearest point of the tramway. The electric resistance of the line is 1·9 ohm; the generating dynamo gives a maximum current of 100 amperes, with 250 volts E.M.F. Since water-power has been applied to produce the electric energy, the working expenses have not amounted to threepence per car mile. The cars are fitted with pitch chain-gearing. Mr. Traill, the managing engineer, informed me that he is satisfied with the working of this gear. An extension of this line is in contemplation. The Bessbrook-Newry Tramway is three miles in length, single rail of 3ft. gauge, with gradients averaging 1 in 85, the maximum being 1:50. In this case also, water-power is available, there being a constant supply of three million gallons a day, with a fall of 28 feet, and part of this is utilised in a turbine which develops 62 horse-power, and actuates two dynamos of the Edison-Hopkinson type, each capable of transforming the mechanical energy of 30 horse-power into electrical energy equivalent to 25 horse power, with an E.M.F. of 250 volts. Two electric cars, each capable of carrying 38 passengers, and weighing, when fully loaded, eight tons, run on this line; besides these, there are six goods waggons, with a capacity for two tons of freight per waggon. A train consists of one passenger car and several waggons, generally three of the latter. The maximum speed attainable is 15 miles an hour, but, to conform to established rules, only 8 to 10 miles an hour are actually made. The line was passed on behalf of the Board of Trade in September, 1885, and from that time to the commencement of the present year, 30,000 train miles were run, 150,000 passengers carried, and 15,000 tons of goods were hauled. The cost of propelling a train containing the full complement of passengers and six loaded waggons is said to be fourpence per mile, including wages, repairs, and rental of water-power. Chain-gearing is employed for the purpose of transmitting the power of the motor to the car-axles. These particulars were kindly given to me by Dr. E. Hopkinson.

* v. *Electrician*, March 25th, 1887, *et sec.*

Mr. Holroyd Smith has devised an underground conductor contained in a channel, which is provided with a slot for the free passage of the electrical contact slide. The most important application of this system on a large scale is that at Blackpool, where it is worked on a line nearly two miles in length. Descriptions of this tramway have appeared in most of the technical journals,* and Mr. Smith having read several papers before scientific societies, I need not dwell upon the details of construction, but will confine myself to a few general remarks. The roadway runs along the coast; ten cars of various sizes comprise the rolling stock, the largest having a seating capacity for 56 passengers, and the smallest carry 30 persons. At the generating stations there are two steam engines, each of 25 horse-power nominal, driving four shunt wound Elwell-Parker dynamos, which give a maximum current of 180 amperes, with 300 volts. The E.M.F. ordinarily employed is 230 volts, which is reduced to 168 volts at one end, and 185 at the other end of the line, the generating station being situated near the middle of the tramway. From all accounts this line has proved quite successful. It was opened in September, 1884. I have not been able to obtain particulars as to the number of car miles run and passengers carried, consequently I cannot establish the relative cost, but Mr. Smith informed me that the expenses do not reach 4d. per car mile. Whilst on the Mödling and the Frankfort tramways the resistances of the conductors are 2 ohms and 1·6 ohm respectively, the calculated resistance of the underground copper tubes at Blackpool is only ·041 of an ohm. We do not know the actual resistance of these conductors, but I should think it must very much exceed that found by calculation, considering the great fall of potential at different points of the line. In one of the papers read by Mr. Holroyd Smith we find some extraordinary statements with regard to insulation, and consequently leakage, in his system of underground conductors:—

"Measurements were taken of the insulation of the line during construction, and 150 yards' length was found to give 4,490 ohms. The average working loss, through leakage, may be taken at 25 amperes, which, at an electromotive force of 200 volts, is equal to 7·2 h.-p."

Profs. Ayrton and Perry have devised a system of conductors which is said to overcome the objections against losses arising through bad insulation. Instead of supplying electricity to one very long, perhaps imperfectly insulated rail, they lay by the side of the railway a well insulated cable, which conveys the main current. A third rail, which is rubbed by the moving train, is divided into a number of sections, each fairly well insulated from its neighbour and the ground; but at any moment only that section which is in the immediate proximity of the train is connected with the main cable, the connections being made automatically by the moving train. The loss of power by leakage is very much lessened through this arrangement, since any possible electrical contact between rails and earth is confined to that particular section upon which the train moves at the time, and connection from the surface rail to the insulated cable is made automatically by the pressure of the vehicles upon springs underneath the conducting sectional rails. Such an arrangement could scarcely be applied to ordinary street tramways, for if the sectional rails were laid flush with the roadway, then any other vehicle would, by its weight upon the rails, cause connection with the main cable.

In order to prevent the possibility of any extraneous force, other than that provided by the electric car, from making contact between surface rail and underground conductor, Messrs. Pollock and Binswanger have devised an ingenious plan. Underneath each electric car is a powerful magnet, and underneath each rail section, within a thoroughly insulated trough, is an armature of iron, which, when attracted by the influence of the passing magnet, makes contact between the cable and the surface rail, and through the latter with the switch of the car motor. No external force but that of a strong magnet, therefore, can draw electrical energy from the insulated underground conductor, and since the surface rail sections are each very much shorter than a car or train, no other vehicle following or preceding in the same track will be influenced by the current. Neither the Ayrton and Perry system nor that of Pollak has been tried on any tramway, therefore no opinion as to efficiency can be formed at present, but these systems seem worthy of an extended trial.

The idea of employing secondary batteries, the stored energy of which sets the motor in motion, and with it the car, suggested itself to the earliest inventors; indeed, the principle of applying batteries to the propulsion of a vehicle containing them was actually demonstrated in the year 1839 by a Scotchman named Robert Davidson. He used primary batteries, which proved a very expensive mode of generating electric currents; the method of storing energy in accumulators was unknown at that time. To-day we are able to convert the energy of a waterfall or of coals into electricity by means of dynamo machines having an efficiency of 90 per cent., and more. The current thus produced can be made to decompose the acidulated water in the secondary cells which contain electrodes, or plates, capable of absorbing the oxygen and hydrogen resulting from the decomposition of water; and, finally, the gases thus stored recombine whenever we desire it, and manifest themselves in the form of electric energy capable of doing mechanical work through an electric motor. As transformations of energy always involve some loss, so there is a loss in this electro-chemical conversion, amounting to from 25 to 30 per cent. In order to establish a comparison between a system having conductors and one having accumulators carried in the cars, we have in the first place to ascertain the efficiency of the conductors in the one case and that of the scondary battery in the other. The efficiency of a conductor depends upon its resistance

* For fully illustrated description of this line, see *The Electrician*, September 10th, 1886.

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and the current transmitted. Let us take, for example, a tramway similar to the one at Mœdling, with a conductor of 2 ohms resistance, 20 amperes of current for each car, and 500 volts E.M.F. at the terminals of the charging dynamo. Supposing that only one car was running on this line, then the waste of energy would be practically *nil* at the commencement of its journey from the generating station, but it would be $20^2 \times 2$ when it approaches the furthest end of the line; the average resistance, or that due to half the length of the condutor, is 1 ohm ; therefore the average loss is only $20^2 \times 1 = 400$ watts, against $500 \times 20 = 10,000$ watts generated by the dynamo; consequently the efficiency of the conductor comes to 96 per cent., since we loss only four per cent. With six cars on the line equally distributed, and using together 120 amperes, the loss will be 14,400 watts out of 60,000 produced at the station, and then the efficiency is only 73⅓ per cent., and so on; by increasing the number of cars, and with it the current, the efficiency gets less and less. With the accumulator system, on the other hand, we have a constant loss, no matter how long the line, provided the quantity of energy stored is sufficient for the time, and it matters not how many cars run at any time on the same tramway. If the cars at Mœdling were fitted with accumulators, then the weight to be propelled would have to be increased by, at least, 20 per cent, and this would entail a corresponding augmentation of power, in order to keep up the same speed, therefore a greater consumption of fuel would be the result. But we have seen that the item of fuel really plays a minor part in the total expenditure ; in fact, it is only about 16 per cent. of the whole, hence we need not look upon the question of the loss of energy with too critical an eye. According to the report issued by the jury of the Antwerp Exhibition, a *resumé* of which has been presented to this society by Captain Douglas Galton, the consumption of fuel with the accumulator car came to 6·161b. per mile, which, at 16s. the ton, costs little more than ½d. This car, however, carried only 34 passengers, and the line was practically level. On the other hand, the steam-engine employed was an old portable engine, which did other work besides charging the accumulators of the tramcar. From practical tests made with cars of my own design, here and on the Continent, I have ascertained that the consumption of fuel need never exceed 8lb. per car mile on ordinary tram lines in towns, provided that the weight of the accumulator carried on the car does not exceed 25cwt.

Viewed from the standpoint of convenience, the propulsion of tramcars through the medium of secondary batteries must be conceded to be second to none. The battery occupies no valuable space when stowed under the seats, while the motor, with its attachments, can be placed underneath the car. There is no interference with the permanent way, and for city traffic such a service ought to be found eminently applicable.

The last system on our list is that of the separate locomotive, carrying accumulators within, and hauling an ordinary car behind it. I have placed this at the bottom of the list because it is the latest, but, from all appearances, it will be the first electric system to be adopted on a tramway in London. The early adoption of electric locomotives is partly due to the progressive spirit, the energy, and perseverance of the North Metropolitan Tramway Company, but mainly, perhaps, to the vigorous enterprise of the Electric Locomotive and Power Company, who exploit the patents of Mr. Elieson, their energetic manager. I have recently had the privilege of witnessing trial trips with six of these locomotive engines. It was a pretty sight to see these vehicles running along Romford-road, one after another, on a dark night, each brilliantly illuminated by its own electric light, an engine smokeless, harmless, and almost noiseless. Mr. Elieson has prepared a diagram, from which the details of construction can be seen. The mechanical connection of the motor with the axles is very ingenious. Instead of the electro-motor being a fixture, it turns round upon a vertical pivot. The horizontal armature shaft carries on its end a bevel wheel, which gears into a large circular rack. At the lower end of the pivot there is mitre gear connected to the driving axle. Reversal of motion can be effected by a clutch which brings one or the other mitre wheel of the axle into gear with that fixed to the pivot. Each of these locomotives weighs nearly seven tons, and this is the only disadvantage one can think of when examining the system. These engines have been ready for some time, they would have been earning money long before now, but for red tape and Acts of Parliament. Before we can run electric cars in this country we must have an Act of Parliament. To obtain one takes a year or more. It causes an immense amount of trouble and expense to get an Act of Parliament, and the worst of it is that each company has to apply separately for it. It is this awkward circumstance which retards the progress of electric locomotion on tramways in this country. Whereas, on the continent of Europe and in the United States of America there are dozens of electric tramways at work, to the satisfaction of everybody, here in England, the home of the dynamo machine, the country where the electric motor has found its highest development, we have so few opportunities to demonstrate their advantageous applications. With regard to America, there are electric tramways at work in New York, Philadelphia, Baltimore, Saratoga, California, New Orleans, Toronto, Detroit, Windsor, Chicago, Cleveland, Montgomery, Denver, and in other parts. The American capitalist encourages electrical enterprise because it is worthy of every encouragement when untrammelled by unnecessary legislation.

I have made out a strong case in favour of electric traction. Any electrician sitting at home in his arm chair can reckon out upon paper what electric locomotion ought to cost, but I have made it my business to travel from place to place and examine into the details of the actual working electric tramways. Practical men want figures based on facts, not estimates. Through the courtesy of the engineers of the oldest lines I have obtained data which renders the question of cost beyond doubt, and we have seen that the entire working expenses of those lines do not exceed—or need not exceed—3½d. per car mile. There is no reason why these expenses should exceed 3d. per mile, when the most efficient machines of the present day will be applied. Electric locomotion includes numerous other applications of the motor besides tramways ; but I must stop short at this stage of the subject, having already trespassed beyond the usual limit of time.

Discussion.

Mr. W. H. Preece, who presided, in opening the discussion, said he was struck with one remark at the end of the paper just read, which stated that "practical men wanted figures based on facts, not estimates ;" and he must confess that in his recollection he had never listened to any paper in which facts were more clearly enunciated than they had been by Mr. Reckenzaun on that occasion. Hitherto it had been very much the practice—which was, perhaps, rather the result of necessity—for those who submitted papers on electrical matters to the society to rely very much upon their imagination and a great deal upon the hopes of the future when those restrictive Acts of Parliament to which Mr. Reckenzaun had alluded should be swept away. The paper clearly showed that there had been great advances made in recent times in the practical application of electricity for locomotive purposes. When it was remembered that the cost of horses on tramways came to from 7d. to 10d. per car mile, it would be seen that there was a very considerable difference between the cost of electrical locomotion and that by means of horses.

Mr. Holroyd Smith complimented the reader of the paper on having given to the society so much information so concisely and in so practical a form. One fact had struck him (the speaker), which should increase their estimate of Mr. Reckenzaun, and that was that Mr. Reckenzaun should have said so little about his own work in connection with this important subject. When they remembered that that gentleman was one of the first, if not the first, to apply secondary batteries to the propulsion of tramcars and had done so successfully, and when they considered that the work he had accomplished in that direction had been taken advantage of by more than one who were now reaping the benefit of his discoveries, it was certainly most commendable on such an occasion that Mr. Reckenzaun should have held his peace upon the subject. He (the speaker) quite agreed with Mr. Reckenzaun on the question of secondary batteries, believing them to be very advantageous and profitable for employment on certain lines. But as Mr. Reckenzaun knew, he disagreed with him as to the comparative efficiency of secondary batteries and the dynamo. He drew two lines of distinction in electric locomotion—direct driving and battery driving. He thought he would be able to show that if they took a line of 5 miles in length, and they desired to run one car to and fro over that line, it would be very much cheaper to do so by means of secondary batteries ; but if, on the other hand, they wanted to run a service of cars—and they knew that tramways did not pay unless the service was frequent, say, at least, every quarter of an hour—then it was very much cheaper to do so by direct driving. It would even cost less to construct a 5 miles line with channel, motors, gearing, and dynamos, in the manner adopted at Blackpool, where they drove direct, than it would do to equip a line of the same length where secondary batteries were to be employed. He would go further, and remind those who had inquired into the subject, that the cost of the construction of the central channel at Blackpool must not be taken as the standing cost in future. At the time it was made he saw that it would be very much better to spend a few hundred pounds more on copper tubes, with the certainty of success, than it would be to keep down the expenditure, and run the risk of failure. The construction of that line had been carried out with a view to safety ; but he could now see that it was possible to construct a line on similar principles at a little more than one half of the cost of the channel work at Blackpool. Therefore, it would be found that direct driving would still more favourably compete with driving by means of secondary batteries. In busy thoroughfares, in towns like London, where the rails were looked upon with the greatest jealousy by omnibus and other drivers, and until the directorates of tram lines were sufficiently familiarised and impressed with the advantages of electrical propulsion, it would take a little time before they would be induced to put an additional rail upon the streets, and until that time arrived—and he hoped it was not so far distant as was generally imagined—he was inclined to think that tramway companies would desire to adopt the system of driving by secondary batteries. But, as he pointed out, in that very room when Captain Douglas Galton read his valuable paper on the subject, he regarded secondary batteries merely as a means of educating the public mind up to the point of adopting the principle of direct driving, which he was quite certain would sooner or later become the universal practice. He must again compliment Mr. Reckenzaun in not having brought before the notice of the society the employment of worm gearing, which that gentleman was the first to employ successfully on a large scale in the propulsion of tramcars. So far as his (the speaker's) experience went he had found it most efficient. Taking everything into consideration, he believed that worm gearing was the best for driving tramcars by electricity, or, he should say, transmitting the power from the motor to the axle. He ought to explain that one reason why he had not given Mr. Reckenzaun more information than that contained in his published reports arose out of that conservatism which he supposed belonged to every Englishman, and especially to every board of directors His directors had requested him not to furnish any information respecting the economy of working at Blackpool, because at the time there was some discussion taking place between them and the town authorities on the question of rating, and it was inadvisable to show how cheaply they were working their line for fear the Corporation would say "You are making too much profit, and you ought to pay higher rates." But he would venture to tell the society this, that the practical working of the Blackpool line was much more economical than any of the figures quoted by Mr. Reckenzaun. He must take exception to one statement in the paper, where it was said that any electrician sitting in his arm-chair could calculate in an evening at what rate a tram line ought to be worked by electricity. That went against his experience absolutely. He found that during the winter

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months, when only three cars were running, and when the number of passengers carried was under 3,000, the total cost was £24 per week; whereas, in the summer months, when the number of passengers carried increased from 3,000 to 45,000, the total working expenses were only £45 when they had 10 cars running instead of three. He had been struck with the figures of the number of passengers carried on the tramways they had heard of, in none of which had they cars to seat the number accommodated at Blackpool, namely, 56. Instead of reckoning the number of people carried by tens of thousands, he had to calculate them by hundreds of thousands. He was now going into the second million of passengers carried on his system, and not a single accident had yet happened in connection with it.

The CHAIRMAN asked whether the company at Blackpool had paid a dividend.

Mr. HOLROYD SMITH had the greatest pleasure in saying that the company not only paid a dividend, but that certain fees due to him, and which he accepted in shares instead of cash, had given him a return of 10 per cent. more than if he had accepted the money.

Sir JOHN JENKINS, M.P., gave some facts in connection with the short railway between Swansea and the Mumbles—one of the oldest in the kingdom— the Act authorising its construction having been passed in 1804. The question with regard to tramways generally, he said, was what was cheapest motive power. He did not think that they had arrived at that state of perfection with electric tramcars which justified them in believing that they were going to supersede the ordinary steam engine when it was practicable to work it. The cost, as he understood, from Mr. Reckenzaun's mode of working was about 3½d. per tram mile. Now, the cost of the railway to which he referred was just about half that amount; therefore very great strides would have to be made with electricity before it could successfully compete with steam. As compared with horse power, of course electricity was very much cheaper, the cost of the former being from 7d. to 10d. per car mile; but to bring the electric motor into competition with steam it would have to undergo a considerable reduction in price.

Mr. MAGNUS VOLK expressed his belief that the use of pitch chains, as employed on the Ryde Pier railway, were a great drawback to successful working, being liable to break down when least expected. He went to the North of Ireland to examine the spur gearing used there, and found that it occasioned so great a noise as to render conversation in the cars an impossibility. He exhibited a piece of double leather belting which had been used over a distance of 50,000 miles, which he thought much more suitable for the purpose. With regard to the Brighton line, it was after many vicissitudes pretty much in the condition it was in when started. They had had storms by sea and prejudice and jealousy by land, but nevertheless the line had been worked nearly four years, travelling 100,000 miles, and carrying about 1,000,000 people, at a cost of 1·92d. per car mile, and it had paid a dividend of 20 per cent. He quite agreed with Mr. Holroyd Smith, that very little cost was involved in working extra cars.

Mr. KAPP expressed his conviction that spur gearing had not yet had a fair trial, maintaining that the noise complained of might be obviated in various ways.

Mr. CAPPER thought that after all the whole question turned upon the cost of working, and he had been very much struck with Mr. Holroyd Smith's statements that evening, as he had been by that gentleman's paper read before the British Association at Birmingham last autumn. In the railway which Sir John Jenkins had mentioned, and in which he (the speaker) was interested, they had to look at the costs with a close eye, and he had never yet come across an electric motor applied to tramcars that it would answer their purpose to adopt instead of steam. He could only assure the society that there was a very great field of enterprise open if it could be shown that a line of six miles in length could be worked cheaper by electricity than by steam.

Major-Gen. BRINE expressed the belief that electricity would never become a great motive power, and could never supersede steam as a means of locomotion. It might do all very well for tramcars or perambulators (laughter), but it would do nothing more ambitious in the way of locomotion.

After a few remarks from Mr. BINSWANGER,

Mr. RICHARDSON (Chairman of the North Metropolitan Tramway Company) agreed that the manner of working tramways would always be determined by the cost, but he did not think that the line at Swansea could be taken as a criterion of the expenditure, say, in London, for the simple reason that the price of coal in the former was very much less than in the latter. He expressed the belief that under better legislation the practical application of electricity as a locomotive power would be largely developed in the future.

The CHAIRMAN said that General Brine was perfectly right in saying that electricity would never be a motive power. It was not so, but rather a means by which motive power was transmitted from one point to another—a means of the transmission of energy. It had advantages and peculiarities that, sooner or later, must make it one of the most useful agents for that purpose that nature had given them. He concluded by moving a vote of thanks to Mr. Reckenzaun, expressing the hope that in the course of another four years he would be able to come before the society and give them the result of his further experience, and that the great prophet of the evening, General Brine, would be present to hear the result.

The vote of thanks having been cordially passed,

Mr. RECKENZAUN briefly replied, and remarked that he had purposely said very little on the subject of secondary batteries, not because he was personally interested in them, but because in this particular paper he had made it a point to devote himself to facts, and not to speculations. He congratulated Mr. Holroyd Smith on the great success of the line at Blackpool, as borne out by that gentleman's statements, He would beg to remind Sir John Jenkins that there was a very great difference between a railway and a steam tramway, the traction force being very much smaller in the former. For instance, it was 8lbs. or 9lbs. a ton on railways, and on tramways it amounted to 25lbs. by reason of the dust and dirt that got into the grooves of the rails. He must point out, however, that in railways the item of repairs was exceedingly heavy. In reply to Mr. Capper, he could only say that as far as he could see at the present time electricity could never compete with steam on ordinary rails. He did not profess that it would do that, but he believed that there was a great future for electricity on tramways, where it had to compete with horse-power and steam-power because tramways worked by steam-power had to be constructed in a peculiar fashion, whereby a great deal of energy was wasted. Steam tramways used up a great quantity of fuel, and, owing to the regulations of the Board of Trade, the steam engine could not be worked to its full advantages. Where there was a waterfall available, as was the case at Portrush and Bessbrook and Newry, he thought electricity under such favourable circumstances could compete with the ordinary steam railways.

RESISTANCE OF FAULTS IN SUBMARINE CABLES.*

BY A. E. KENNELLY, M.S.T.E.

(Concluded from page 487.)

APPENDIX I.

TABLE IX.

Table showing the resistances experimentally observed with different exposures of cable core in sea water, compared with the amounts calculated by the laws of inverse square roots from a single observation as basis.

The core selected was of { 120lbs. copper / 175lbs. g. p. } per knot.

30 Minottis = 34·49 volts } testing battery.
410 ω internal resistance }

Bridge 100 ω : 1,000 ω. Zinc to line. Immediate false zero.

To maintain the proportion in the surfaces, the section of the copper strand was capped in each experiment with insulating material. All the observed readings were steady.

Current through Exposure. Milliamperes.	Resistances observed.					Resistances calculated from reading No. 4, column I. of observed readings, by laws inverse squares.				
	Approximate Length and Surface					of Conductor exposed in cms.				
	I. Cms. 8	II. Cms. 4	III. Cms. 2	IV. Cm. 1	V. Cm. 0·5	I. Cms. 8	II. Cms. 4	III. Cms. 2	IV. Cm. 1.	V Cm. 0·5
	Sq. cms. 5·872	Sq. cms. 2·936	Sq. cms. 1·468	Sq. cm 0·734	Sq. cm 0·367	Sq. cms. 5·872	Sq. cms. 2·936	Sq. cms. 1·468	Sq. cm. 0·734	Sq. cm 0·367
	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.
1	26	3[illegible]	50	72	102	28	39·6	56	79·2	112
2	18	28	35·5	55	70·5	19·8	28	39·6	56	79·2
3	16	22·5	32	45	61	16·2	22·9	32·4	45·8	64·8
4	14	20	27·5	38	54	...	19·8	23	39·6	56
5	12·7	18·5	25·5	36·5	48·5	12·5	17·7	25	35·4	50
6	12	17	24·5	33·5	45	11·5	16·2	22·9	32·4	45·8
8	10	14·5	19·5	28	37	9·9	14	19·8	28	39·6
12	8·5	12	17	23	33·7	8·1	11·5	16·2	22·9	32·4
16	7·5	10·5	14·7	20	28	7	9·9	14·0	19·8	28
20	6·5	9·7	12·9	18·4	24·6	6·3	8·9	12·5	17·8	25
24	6·2	9·0	12·3	17	23	5·7	8·1	11·5	16·2	22·9

The discrepancies in the above table between the resistances observed and calculated nowhere exceed 12 per cent., but the observed readings include errors of electrical measurement and of surface measurement, besides the second error of polarisation mentioned in the paper, *i.e.*, the stronger currents are probably overstated, thus making the resistance observed at those currents too high.

APPENDIX II.

THE ELIMINATION OF THE SECOND POLARISATION ERROR.

The correction for the alteration in the strength of the testing current to line owing to the earth current or polarisation electromotive force acting in it could be arrived at, when necessary, by observing a few of the readings to true zero as well as to false zero.

For if $a\,y$ is the resistance which at any given current-strength balances to truer zero, then y is the apparent resistance of the line and break to truer zero.

Referring to the figure, if $\pm\, e$ be the electromotive force owing to earth current or polarisation in the line, it can be readily proved that

$$e = \frac{(x - y)\,E}{\mu + y + \frac{(\rho + b)\,(a + 1)}{a}}.$$

Thus, when y is greater than x, e is negative, or acts against the testing current.

Owing to loss of time in false zero reading x is generally greater than its true amount, so that e is generally too small. When a is 10 or 100,

* Paper read before the Society of Telegraph-Engineers and Electricians.

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TABLE SHOWING RESULTS obtained with Broken Cable No. 6; a Battery of 88 volts, 350 ω total internal resistance; and the Zinc Pole to Line.

I. Number of milli-amperes required.	II. Constant, $\frac{88 \times 1000}{11.} \div n$.	III. $b + \frac{10\mu}{11} = \left\{\frac{10}{11}(100) + 350\right\}$	IV. First Difference.	V. $\frac{10x}{11}$.	VI. Second Difference, ρ.	VII. Observed with ρ, x false zero.	VIII. Observed with ρ, y true zero.	IX. Difference. $(y-x)$.	X. $\rho+b$.	XI. $\frac{11}{10}(\rho+b)$.	XII. $y+\mu$.	XIII. $y+\mu+\frac{11}{10}(\rho+b)$.	XIV. $-e$ volts.	XV. $\frac{E-e}{E}$.	XVI. Corrected Current. Milli-amperes.	XVII. Assumed Distance Break.	XVIII. Consequent Resistance of Break observed.	XIX. Resistance of Break calculated from No. 4.
					Ohms.	Ohms.	Ohms.	Ohms.	Ohms.							Ohms.	Ohms.	Ohms.
1	80,000	440	79,560	500	79,060	550	870	320	79,410	87,351	970	88,321	0·32	0·9964	0·996	318	232	274
2	40,000	...	39,560	454	39,106	500	630	130	39,456	43,402	730	44,132	0·26	0·9970	1·994	...	182	194
3	26,667	...	26,227	432	25,795	475	...	...	...	...	...	...	...	...	...	...	157	158
4	20,000	...	19,560	414	19,146	455	520	65	19,496	21,446	620	22,066	0·26	0·9970	3·988	...	137	...
5	16,000	...	15,560	404	15,156	445	...	...	...	...	...	...	...	...	...	...	127	123
6	13,333	...	12,893	395	12,498	435	...	...	...	...	...	...	...	...	...	...	117	112
7	11,429	...	10,989	386	10,603	425	...	...	...	...	...	...	...	...	...	...	107	104
8	10,000	...	9,560	378	9,182	416	447	31	9,532	10,485	547	11,032	0·24	0·9973	7·978	...	98	97
9	8,889	...	8,449	370	8,079	407	...	...	...	...	...	...	...	...	...	...	89	91
10	8,000	...	7,560	366	7,194	403	...	...	...	...	...	...	...	...	...	...	85	86
11	7,273	...	6,833	363	6,470	400	...	...	...	...	...	...	...	...	...	...	82	82
12	6,667	...	6,227	361	5,866	397	...	...	...	...	...	...	...	...	...	...	79	79
13	6,154	...	5,714	358	5,356	394	415	21	5,706	6,276	515	6,791	0·27	0·9969	12·960	...	76	76
14	5,714	...	5,274	356	4,918	392	...	..	...	...	...	...	...	...	...	...	74	73·2
15	5,333	...	4,893	354	4,539	389	...	...	...	...	...	...	...	...	...	...	71	71·8
16	5,000	...	4,560	351	4,209	386	405	19	4,559	5,015	505	5,520	0·30	0·9966	15·946	...	68	68·5
17	4,706	...	4,266	348	3,918	383	...	...	...	...	...	...	...	...	...	...	65	66·5
18	4,444	...	4,004	347	3,657	381·5	...	...	...	...	...	...	...	...	...	...	63·5	64·3
19	4,210	...	3,770	345	3,425	380	...	...	...	...	...	...	...	...	...	...	62	63
20	4,000	...	3,560	344	3,216	378·5	395	16·5	3,566	3,923	495	4,418	0·32	0·9964	19·938	...	60·5	61·6
21	3,810	...	3,370	343	3,027	377	...	...	...	...	...	...	...	...	...	...	59	59·8
22	3,637	...	3,197	342	2,855	376	...	...	...	...	...	...	...	...	...	...	58	58·4
23	3,478	...	3,038	341	2,697	375	...	...	...	...	...	...	...	...	...	...	57	57·1
24	3,333	...	2,893	340	2,559	374·5	390	15·5	2,909	3,200	490	3,690	0·37	0·9958	23·899	...	56	56·0
25	3,200	...	2,760	340	2,420	374	...	...	...	...	...	...	...	...	...	...	...	...
						Readings repeated as follows, with the Copper Pole to Line.												
1	80,000	...	79,560	436	79,124	480	1,280	800	79,474	87,421	1,380	88,801	0·90	0·9898	0·990	318	162	104
2	40,000	...	39,560	363	39,197	400	860	460	39,547	43,502	960	44,462	0·91	0·9896	1·979	...	82	73·6
3	26,667	...	26,227	345	25,882	380	690	310	26,232	28,855	790	29,645	0·92	0·9895	2·969	...	62	60
4	20,000	...	19,560	336	19,224	370	610	240	19,574	21,521	710	22,231	0·95	0·9892	3·957	...	52	...
5	16,000	...	15,560	332	15,228	365	560	195	15,578	17,136	660	17,796	0·96	0·9891	4·946	...	47	46·5
6	13,333	...	12,893	329	12,564	362	512	150	12,914	14,205	612	14,817	0·89	0·9899	5·939	...	44	42·5
7	11,429	...	10,989	328	10,661	361	490	129	11,011	12,112	590	12,702	0·89	0·9899	6·929	...	43	39·3
8	10,000	...	9,560	327	9,233	360	500	140	9,583	10,541	600	11,141	1·10	0·9875	7·900	...	42	36·8
9	8,889	...	8,449	326	8,123	385	...	...	...	...	...	...	...	...	...	...	67	34

In the above table ρ is obtained by the formula $\rho = \frac{1000\,E\left(\frac{a}{a+1}\right)}{n} - \left\{b+\mu\left(\frac{a}{a+1}\right)\right\} - \frac{a\,x}{a+1}$. The bridge being 100 ω : 1000 ω, $a=10$.

The successive steps by which ρ is found are shown in Columns II. to VI.

The observed readings to false zero are shown in Column VII. Similar readings taken, however, to true zero are given in VIII.

From the difference between the readings to true and false zero the strength of the opposing earth current is found by the formula $e = E \times \frac{x-y}{y+\mu+\frac{(b+\rho)(a+1)}{a}}$, the successive steps being shown in Columns IX. to XIV.

The current strength passing through the break is then corrected for e by multiplying the values in Column I. by $\frac{E-e}{E}$ in Column XV., and the true current strengths thus deduced appear in Column XVI.

The distance of the break was assumed to be, from the series, 318 ω. The corresponding resistances of the break observed are given in Column XVIII.

Column XIX. gives the calculated resistance of the break, by inverse square roots, from the observed resistance with 4 milliamperes.

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the actual strength of current passing through the break when this value of x was observed would be, approximately,

$$\text{Calculated current} \times \frac{E \pm e}{E}.$$

So that by observing x and y together at one or two points in the series the numerical correction to the current strengths can be subsequently applied.

APPENDIX (November, 1886).

The results with broken cables 5 and 6 have been obtained since the above paper was written.

In the case of No. 6 the full correction of the current strength passing through the break is added, taking the electromotive force of polarisation set up by the break and earth current into account. The comparison of Columns I. and XVI. shows how slight the correction becomes with a battery of considerable strength. A series is also shown with the copper pole to line. This broke off abruptly on reaching 9 milliamperes, the resistance of the break rising suddenly from 42 ω to 67 ω, and increasing. The readings in this series are lower than with the zinc current, but not so uniform.

For practical ship's use the resistance ρ may be conveniently calculated for a given battery, and checked from day to day. The values of ρ for 3, 4, 5, 6, and 12, 16, 20, and 24 milliamperes being thus kept ready for use, four pairs of quadruple readings can generally be obtained with any break that may present itself in ten or fifteen minutes, the distance of the break for any given pair being then almost evident from inspection.

BROKEN CABLE No. 5.

Zinc pole to line. 38·75 volts, 85 ω internal resistance battery. Bridge ratio, $\frac{1000}{100}$.

Milliamperes through Break.	Resistance observed, corrected for temp.	Distance of Break assumed.	Resistance of Break observed.	Calculated Resistance of Break.
	Ohms.	Ohms.	Ohms.	Ohms.
1	1,700	1,532	168	156·5
2	1,645	...	113	113 7
3	1,620·5	..	88·5	90·4
4	1,610·25	...	78·25	...
5	1,600·5	...	68·5	69·9
6	1,595·5	...	63 5	63·9
7	1,590·5	...	58 5	59·2
8	1,587·5	...	55 5	55·3
9	1,585	...	53	52·2
10	1,582·5	...	50·5	49·5
11	1,580·5	...	48·5	47·2
12	1,578	...	46	45·2
13	1,576	...	44	43·4
14	1,573·5	...	41·5	41·8
15	1,571·5	...	39 5	40·4
16	1,570·5	...	38·5	39·1
17	1,569·5	...	37 5	38
18	1,568 5	...	36·5	36·9
19	1,567·5	...	35·5	35·9
20	1,567·5	...	35·5	35
24	1,565 5	...	33·5	31·9
25	1,564·5	...	32·5	31·3

DISCUSSION.

Sir HENRY MANCE, referring to his own paper on a similar subject, complained of the hostile spirit in which it had been criticised at the time, and in his absence. He ventured to assert, after an experience of cable testing extending over a great number of years, that the method he had described in that paper, and which had been largely employed ever since, was not old or superfluous, but that it was a distinct improvement on the old methods. Still he had only succeeded in eliminating earth currents and polarisation currents from the test; whereas in the paper just read the resistance of the fault itself was also got rid of, and for this we were indebted to Mr. Kennelly. The law laid down by the author was confirmed by certain items in his, Sir H. Mance's, own paper; and he believed that we had now in our possession formulæ which would enable even the least experienced observer to localise the fault in a cable with tolerable accuracy. Mr. Kennelly had gone a great way towards making cable testing an exact science.

After a few observations from Sir C. BRIGHT, the President, relating to his earlier experiences when cable faults were localised very successfully without such aids to calculation as are furnished in papers of this kind,

Mr. HAROLD ANSELL gave an account of Mr. Kennelly's method actually applied on board ship. In one case the distance was 35 miles, and the test was only 1 ω out. Another instance gave 3 ω or 4 ω out, but the condition of the breakage was exceptional, and this was the largest error he had observed in working with Mr. Kennelly's formulæ. As regards Sir H. Mance's method, its great defect, in respect to the long lines with which he, Mr. Ansell, had to do, was that he could never get it to work over 100 miles. Lumsden's method also always left something to allow. Later on, in replying to a question of Prof. Ayrton,

Mr. ANSELL described diagrammetically the manner of manipulating the apparatus when applying Mr. Kennelly's method.

Mr. W. GRANVILLE suggested the advantage of employing both methods, that of Sir H. Mance and this of Mr. Kennelly.

Mr. DONOVAN, thought that Mr. H. Mance had rather mistaken the drift of the criticism which followed on his paper, and which was not so hostile as he seemed to imagine. While speaking highly of Mr. Kennelly's paper he, Mr. Donovan, thought that all such tests as those referred to are more or less affected by the circumstance attending the breakage and the conditions of the broken end—whether, for example, it is dangling over a rocky ledge, or buried in a muddy bottom.

Prof. AYRTON reviewed the process of testing before and after Mance's method, and explained the *rationale* of Kennelly's method, which was very ingenious and a great stride in cable testing.

Prof. ADAMS pointed out the risk of error through the reversal of current from and to the fault; and agreed with Mr. Granville that from a combination of the Mance and Kennelly methods a good practical one would follow.

Mr. RYMER JONES suggested that a weak point in this test was that the law only applied to cases where the current through the fault does not exceed 25 milliamperes, and is therefore not applicable to long cables; whereas with Mance's method we can use a higher power.

A hearty vote of thanks to Mr. Kennelly concluded the proceedings.

COMPANIES' MEETINGS & REPORTS.

United River Plate Telephone Company (Limited).

To comply with the Companies Act of 1867 and the Articles of Association of the Company, the first ordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, on the 15th inst. Lord Thurlow presided.

The SECRETARY (Mr. J. Owen Unwin) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, it will not be necessary for me to take up much of your time on this occasion, as you know it is the first meeting that this Company has held since its formation, and it is purely confined to the business which is prescribed by the Act regarding statutory meetings. The object of the statutory meeting, as I understand it, is to enable the shareholders to have an early opportunity of bringing any grievance that they may have, or think they have, either in the way of allotment or as to the terms of the prospectus, or any other circumstance of that nature, to the knowledge of the Board, and, if desirable, to endeavour to seek a remedy. I think, however, that this Company has been inaugurated on so favourable a financial basis that neither of the grievances to which I have alluded can be held to apply in this instance, and our proceedings will therefore be of the stereotyped formal character. The Company was registered on the 17th December, and this meeting is therefore held within two days of the latest date for which it could have been called. We fixed it for this late date in order to have the results of as much experience as possible of the working of the new company to lay before you. You know that the capital was fully subscribed, and that it was consequently in our power to pay the vendor companies the sums agreed upon in the manner provided. The total sum paid was £290,000, in equal proportions, to each of the vendor companies. Of this amount £170,000 was paid in cash, £40,000 in 7 per cent. debentures, and £80,000 were taken in 16,000 fully-paid shares by the vendor companies. This result was, of course, very satisfactory to the Board of Directors, and I think it must have been equally satisfactory to the subscribers to know that the contemplated arrangements were able to be carried out exactly as intended. Having thus successfully inaugurated the Company, the first thing that we had to consider was the question of a Stock Exchange quotation. You are aware of the value which is attached by shareholders to this matter. You know also that the Stock Exchange Committee sometimes make difficulties; and perhaps they are getting more critical than they were in times gone by. However, we approached the committee through the recognised channels, and I am bound to say that we received from them and from the secretary the greatest courtesy and the most prompt attention. Our books were all placed at their disposal without reserve, and one or two interviews with the secretary satisfied him and satisfied his committee that everything in connection with the formation of the Company was of a straightforward and satisfactory character, the result being that a Stock Exchange quotation was granted to the Company in the shortest time in which that result is ever accomplished. The question of a quotation is, of course, a matter of very great moment to all who hold stock in this Company, and I think the successful result of our endeavours in this direction is a source of satisfaction and congratulation. We thus entered fairly established on our work. The properties of the two vendor companies at Buenos Ayres were transferred to the new company in the manner proposed, and reported by Mr. Adolf Fels to us by cable. Then we had to go into the question of stock, as we were taking over plant, instruments, and everything else, and I am happy to inform you that the books and returns we received proved eminently satisfactory, and that the question of adjudication of prices was considered—the two vendor companies meeting us in an amicable spirit—and no sort of difficulty has arisen. But it must be remembered that a board of directors in London has naturally to face certain difficulties in dealing with a business, and in managing the affairs of a company situated, as one may say, almost at the Antipodes. We have to rely mainly on the reports that we receive from our trusted agent out there. The only possible way of conducting such a business satisfactorily is to appoint the best manager you can find available, and to place as much confidence in him as you fairly can. That, gentlemen, is the course which we have pursued. You are all aware of the circumstances under which Mr. Adolf Fels became our manager in the River Plate. You know that Mr. Fels is a man of very great ability and energy, and that he has played a leading part in the building up of this great business to which we have succeeded. The circumstances under which the two vendor companies became amalgamated into the new company were somewhat peculiar,

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For one thing, subscribers to these two companies had previously—that is, those who wished to be in connection with most of the business houses in Buenos Ayres—subscribed practically to the two companies. In future they will only have to subscribe to the one. It could not, of course, be expected that subscribers were to receive double the accommodation without paying more than a single subscription. From the very first it was naturally anticipated that there would be a rise in rates. That rise was calculated from the first by the two vendor companies, whom I may call the promoters, and the bargain which was made by them on that assumption forms practically the financial basis on which we now stand. All the figures and calculations as to dividend were based on that agreement, and it was absolutely necessary that it should be carried out if we were to earn the dividend anticipated, and which shareholders were led to expect. Much was left—in fact, everything was left—to Mr. Fels' discretion as to the exact moment when the rise in rates was to take place, but it was a matter which we ourselves considered we should be consulted upon, and we expected that a good deal of consideration, and discussion, and exchange of views with Mr. Fels would take place before such a rise in rates took effect. Mr. Fels, however, took an opposite view. He was aware of the confidence which the vendor companies and the new company placed in his judgment, and he deemed that the change of rates, being a very important one, should necessarily be made coincident with the formation of the new company. He foresaw difficulties and possible dangers in delay, and he took upon himself the responsibility—the very great responsibility—of making that rise in rates without consulting the London Board. That step once taken was irrevocable. That it should have caused a certain amount of ill-humour, and probably dislike, was only natural. People are always apt, in a matter of this kind where they are called upon to pay double what they paid before, to regard it in a hostile light. What is actually the case is, that subscribers who were formerly only on the list of one company now have double the accommodation, while those who subscribed to both now pay practically the same with increased convenience. Of course those who previously only subscribed to one company now have to pay more, for the increased number of subscribers with whom they are able to hold communication, and for, I I hope, the improved service, and for various other changes which I am not at liberty at present to mention. Now that the excitement which ensued upon this rise in rates has to some extent subsided, I am one of those who begin rather to feel that it is perfectly possible that in thus acting Mr. Fels may have done the right thing at the right time in taking the bull by the horns and getting the rise over at once on his own responsibility. It, of course, has been an anxious time for us; we read the newspapers like other people, and we have noticed the jubilant prophecies about the formation of other companies with underground wires and all sorts of imaginary advantages, and it is satisfactory to us to see how the agitation has now calmed down and almost disappeared. We have received advices down to the 18th of March, and feel justified to look forward to our weekly advices being more and more favourable, to a return of confidence in Mr. Fels personally, and to everything proceeding in a manner which as shareholders we ardently desire. I will now give you a few of the latest figures received to show you the position in which the business actually stands. The total number of subscribers to the two vendor companies on the 15th December last was 3,548. From that total we have to deduct 398 as duplicates, leaving an actual total of 3,150. A very large proportion of our subscribers are monthly subscribers, a system which I think is a very great evil, and perhaps some day we may be able to substitute for it a six monthly or an annual tariff, which would be for the convenience of the public itself, and undoubtedly for the benefit of the company. The monthly system to a company like ours is a great inconvenience, while it lends itself to any momentary panic. Any excitement got up from any cause, however futile, has the effect of influencing subscribers to withdraw. Considering the rather serious nature of the excitement which occurred on the rise of rates, I think you will be satisfied to know that the total number of withdrawals we have had out of a total of over 3,000 during the last three months is only 150, and most of these I understand are now coming back. There is one other figure which I desire to give you, of the utmost importance, and highly satisfactory. It was cabled to us only the day before yesterday, and was to the effect that during the first eight working days of April 11,421 dollars were received by Mr. Fels in monthly subscriptions, mostly in advance. As regards the fear of competition, which we were led to suppose was very great, I am not myself inclined to attach any very great importance to it. It is not such an easy thing to oust a telephone company when it has once got possession. For a certain time, when the recent excitement commenced, the authorities at Buenos Ayres did not exercise due vigilance in punishing people who were guilty of wire cutting. They have now seen the error of their ways, and renewed active prosecution for this offence. The result is that we are in communication now all over Buenos Ayres in our previous perfect condition. A multiple switchboard is being constructed at Antwerp on the most improved principle, and will shortly be sent out. This will enable our subscribers to interchange communication with the greatest facility and convenience, and I have no doubt myself, and I almost venture to prophesy, that when that switch-board is fixed and matters have quite calmed down, our business will probably grow at the very least to the extent that we anticipated. I do not feel that I should be justified in taking up more of your time to-day. We are taking steps, which I do not think it necessary to explain, to exercise a close supervision on all that goes on at Buenos Ayres. We have despatched an officer out there in whose judgment and experience we have very great reliance, and are in almost momentary expectation of receiving a report from him as to the state of affairs and public opinion in the River Plate. I may add that the present attempts to establish rival companies has come to nothing. The statutory capital has in no case, I believe, been subscribed; it may have been underwritten to a certain extent, but even if it were subscribed I have no doubt whatever that a sufficient working capital would not be subscribed; and it is open to very great doubt whether such a company would be able to procure instruments ready to their hands. Then you must also consider who would join them, a new company, with all their friends and the commercial houses already on any company's system. I therefore think that from competition we have absolutely nothing to dread. We have urged on Mr. Fels—I have written to him privately several times, and the secretary has also written—to use the utmost endeavour to recover the ground he has lost, and I believe myself that the steps we have taken and the measures that we contemplate will be fully sufficient to attain the end we have in view. I have no resolution to move, but I shall be happy to any questions that shareholders may wish to put.

Major Wood said he had known Mr. Fels in connection with work in South America, and though he had differred from that gentleman, he was confident that Mr. Fels' action in connection with the Company had been dictated by solid experience in the River Plate, and by absolute integrity.

The Chairman expressed the Directors' satisfaction at the remarks of Major Wood, and observed that Mr. Fels was a very large holder of shares in the Company.

On the motion of the Chairman, seconded by Mr. Cunningham, Major Henry T. G. Fitzgerald and Mr. Frederick Green were re-elected directors; and Messrs. Cooper Brothers were afterwards appointed auditors.

A vote of thanks to Lord Thurlow was unanimously agreed to.

The Chairman, in reply, said he looked forward to the Company being able in the summer to pay a good dividend.

The Telephone Company of Ireland.

On Friday last the eighth ordinary general meeting of the proprietors was held in the offices of the Company, Commercial Buildings, Dublin. The chair was occupied by Mr. E. D. Gray, M.P.

The Secretary having read the notice convening the meeting, the report and statement of accounts (vide *Electrician*, April 8), were taken as read.

The Chairman, in moving the adoption of the report and accounts, said they would see by the report that their business had progressed, not, perhaps, by leaps and bounds, but steadily; and he had no reason to anticipate that this steady progress would not continue in the future as in the past. On the 31st of December, 1885, the number of subscribers was 878, last year the number was 915, and considering the depression in business and the many difficulties which telephone companies had had to face, he did not consider that that was unsatisfactory. Their profits for the year, as they would see by the report, were sufficient to admit of the payment of an increased dividend on the ordinary shares at the rate of 1½ per cent. for the second half of the year, as against ¾ per cent. for the corresponding half of 1885, but they considered it more prudent to commence to build up a reserve fund and strengthen it by the addition of a substantial sum and keep the dividend at the former figure, ¾ per cent. They had opened an exchange in April last at Dundalk, on the call fee system, and found the trial satisfactory. It had reached the paying point, and there was no reason why it should not prove still more remunerative. Encouraged by that experiment they contemplated opening exchanges in other towns on the same system. For this purpose, and in order to provide the necessary capital to meet the expenditure requisite for the increasing business of the Company, they considered it desirable that they should have the power of raising such capital by the issue of additional shares, instead of by calling up the unpaid balance due upon the 29,776 preference shares partly paid in the event of their deeming it desirable, in the interests of the shareholders, that such a course should be adopted at the time additional capital may be required. They would ask the shareholders to give them the power of issuing new shares, or to permit existing shareholders to exercise the option of paying up a call. He might say that he was of opinion that the few shares that had changed hands had done so at ridiculously low prices. In whatever they did they would, of course, be actuated by an anxiety for the best interests of the Company. Resolutions would be proposed on this subject, and, in conclusion, he would move the adoption of the report and accounts.

Alderman Winstanley seconded the proposition, which was carried.

The Chairman then proposed "That a dividend at the rate of three-quarters per cent. per annum upon the ordinary share capital of the Company for the year ended 31st December, 1886, be declared, and that the interim dividend paid in August last for the half year ended 30th June be confirmed."

Mr. H. G. Erichsen seconded the motion, which was carried.

The Chairman next proposed "That the Directors be, and they are hereby, authorised to issue 25,000 preference shares of £1 each, being the unissued portion of the total of 75,000 preference shares authorised by the Articles of Association."

Alderman Dillon seconded the proposition, which was carried.

The Chairman also moved "That, subject to the consent of the United Telephone Company, under seal, the Directors have power to issue the whole or any portion of said 25,000 unissued preference shares of £1 each referred to in the preceding resolution, upon such terms and subject to such conditions as they may think fit."

Mr. A. Dudgeon seconded the motion, which was carried.

Mr. Erichsen moved that the retiring Directors—Mr. E. D. Gray, M.P., and Mr. A. Dudgeon—be re-elected.

Alderman Winstanley seconded the motion, which was carried.

The Chairman expressed his thanks, and said that any deficiency on his part was most abundantly made good by the labours of his colleague (Mr. Dudgeon), who was indefatigable, and to whom they were very much indebted.

On the motion of Mr. Daly, seconded by Alderman Dillon, Mr. John

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M. Kean was reappointed auditor; and it was also resolved that the joint remuneration for the year ending December, 1887 for the auditors appointed by this Company and the United Telephone Company be 50 guineas.

A vote of thanks to the Chairman brought the proceedings to a close.

Eastern Extension, Australasia, and China Telegraph Company.

Report and accounts of the Directors for the half year ended December 31st, 1886, to be submitted to the twenty-seventh ordinary general meeting to be held at Winchester House, 50, Old Broad-street, E.C., on Wednesday, 27th inst., at 2 o'clock :—

The gross receipts, inclusive of Government subsidies, have amounted during that period to £216,956. 2s. 8d., against £247,017. 6s. 4d. for the corresponding half year of 1885, showing a decrease of £30,061. 3s. 8d., or about the same falling off as in the first half year. Nearly the whole of this decrease occurred in the first three months, since which time the receipts have shown a marked improvement. The reduced tariffs were, moreover, in operation during the whole six months, from which alone a loss of £25,000 was anticipated. The working and other expenses, including £30,639. 15s. 6d. for cost of repairs to cables and expenses of ships, absorb £80,066. 10s. 11d., against £71,473. 6s. 9d. for the corresponding period of 1885, leaving a balance of £136,889. 11s. 9d. From this is deducted £4,224. 9s. 4d. for income-tax, and £41,595 for interest on debentures and contributions to sinking funds, leaving £91,070. 2s. 5d. as the net profit for the half year, which, with £34,980. 5s. 8d. brought forward from the previous half year, leaves an available balance of £126,050. 8s. 1d. One quarterly interim dividend of 1¼ per cent. has been paid for the half year, and it is now proposed to distribute another of like amount, together with a bonus of 2s. per share, payable on the 28th April, making with the interim dividends paid for the first half year a total distribution of 6 per cent. for the year 1886. The balance of £38,550. 8s. 1d. has been carried to the general reserve fund, which, after being debited with the cost of the Singapore-Penang (renewal) cable, amounting to £53,245. 3s. 8d., now stands at £569,440. 16s. 10d. In pursuance of the conditions upon which the issue was made, 108 of the company's 5 per cent. debentures of 1880 were drawn by lot on the 30th ultimo for payment at par 1st May next.

The company's maintenance ships have been employed on various cable repairs during the half year, but no interruptions of importance occurred to the Company's system beyond the breakdown simultaneously of the Madras-Penang and Rangoon-Penang cables referred to in the last report. The difference with the Government of New Zealand respecting the renewal of the New Zealand cable subsidy, which was fully referred to at the last general meeting, resulted in the raising on the 1st November last, of the tariff for inter-colonial telegrams. Subsequently a proposal made by the Agent-General of New Zealand was accepted for reverting to the former tariff for a period of six months, in order to give an opportunity to the Parliament, on its re-assembling, to come to a decision on the subject. It is expected that the whole question of telegraphic communication will shortly be considered at the Colonial Conference now assembled in London. The land line belonging to the South Australian Government between Port Darwin and Adelaide has been well maintained during the half year under review.

In accordance with the Articles of Association, George Garden Nicol, Esq., and John Pender, Esq., retire by rotation, and offer themselves for re-election. The retiring auditors, Mr. Henry Dever and Messrs. Quilter, Ball and Co., also offer themselves for re-election.

Indo-European Telegraph Company (Limited).

Report and accounts of the Directors for the year ended 31st December last to be presented to the twentieth ordinary general meeting of the members of the Company to be held at Winchester House, 50, Old Broad-street, E.C., on Monday, the 25th inst., at 12 o'clock noon :—

The Company's revenue from all sources for 1886 amounted to £104,583. 0s. 7d., as compared with £116,150. 3s. 1d., showing a decrease of £11,567. 2s. 6d. The expenses were, on commercial and general account £27,307. 2s., on maintenance account £23,466. 5s. 8d., including £242. 8s. 9d paid to the Russian Government; total £50,773. 7s. 8d., as against £51,597. 8s. 11d., a decrease of £824. 1s. 3d. Deducting the above expenses, taking credit for £1,456. 5s. 1d. balance brought over from 1885, and debiting income-tax, there remains the sum of £53,593. 6s. 7d. From this amount £10,000 has been placed to reserve, and that sum, together with £10,625, amount of interim dividend, have to be deducted, leaving a balance of £32,968. 6s. 7d. The Directors now propose the declaration of a dividend for the last six months of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 20s. per share, both free of income-tax, making in all 10 per cent. for the year, carrying forward £1,093. 6s. 7d. to the credit of 1887. The directors have purchased the chief interest in the Company's lease of its central offices for the sum of £10,362 at 4½ per cent., and have paid for the same out of the reserve fund. The two special circuits secured from London to Teheran, by arrangement previously reported, work very satisfactorily, and the Company's system generally continues in excellent order. The diminution of revenue as compared with 1885 is largely owing to the traffic of that year having been considerably increased by exceptional causes, fully explained in last year's report. There is, however, an actual falling off in the number of words transmitted, notwithstanding the reduction of the tariff introduced from the 1st of July last, so that in addition to the loss per word occasioned by the reduced rate the business itself has decreased. This decrease is still going on, but the directors hope that looking at the revival of trade now becoming apparent a rebound may take place. As frequently reported to the shareholders, the Company's system is capable of dealing with many times the number of messages that can be hoped for from the Indian and Trans-Indian business. The Company, after prolonged negotiations with the Russian Government, has succeeded in obtaining the privilege of utilising some of the idle time of the wires by carrying certain South Russian correspondence. The tariff received for the work performed is very small, but will contribute to the general revenues. The arrangement took effect from January of the current year. The following Directors retire by rotation, and offer themselves for re election :—Major-General G. B. Tremenheere, R.E., and J. Herbert Tritton, Esq. The auditors, Messrs. C. F. Kemp, Ford and Co., public accountants, retire and offer themselves for re-election.

Reuter's Telegram Company (Limited).

Report of the Directors to be presented at the twenty-third ordinary general meeting of the shareholders, to be held at the Company's offices, 24, Old Jewry, E.C., at noon on Wednesday, the 27th inst. :—

The Directors beg to report that the net profits for the year ending 31st December last, after payment of current charges, and deducting rebate on unexpired subscriptions, amount to £6,772. 5s. 4d., including £613. 5s. 10d. brought forward from the last account. An interim dividend of 2½ per cent. was paid in October last, and the Directors now declare a further dividend of 5 per cent., making a total distribution, free of income-tax, of 7½ per cent. for the year. This will absorb £5,585. 8s., and after adding £1,000 to the reserve fund, there will remain a balance of £186 17s. 4d. to be carried forward. In conformity with the Articles of Association, Colonel James Holland retires from the direction, but offers himself for re-election. The auditors, Messrs. Quilter, Ball and Co., also offer themselves for re-election.

CITY NOTES.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 15th inst. amounted to £3,611.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 15th inst. amounted to £2,921.

NOTICE OF REMOVAL.—The Union Electrical Power and Light Company (Limited) have removed their offices from 127, Cannon-street to Palace Chambers, Westminster.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. April 20.		Business Done Week Ending April 20. Highest.	Lowest.
Anglo-American	36,	37	36	35¾
Do. Preferred	58¼,	59¼	59	57¾
Do. Deferred	15,	16	15½	14¾
Brazilian Submarine	10⅝,	10⅞	10⅞	10¾
Cuba	11¾,	12¼	12⅜	12¼
Do. Preference	18,	19	—	—
Direct Spanish	2¾,	3	—	—
Do. Preference	7,	8	7¾	—
Direct United States Cable	9,	9½	9½	9
Eastern Telegraph	10¾,	11	11	10⅝
Do. 6 per Cent. Preference	13½,	14	13⅝	—
Do. 5 per Cent. Debentures, 1899	105,	108	106½	106
Eastern Extension	12⅛,	12⅝	12⅜	12⅛
German Union	9,	9½	—	—
Globe Telegraph and Trust	5½,	5¾	5 11-16	5⅝
Do. Preference	12⅜,	12⅝	12 11-16	12⅝
Great Northern	13¾,	14	14	13¾
Indo-European	35½,	36½	—	—
Reuter's	6¾,	7¼	7¼	—
Submarine	180,	190	—	—
West India and Panama	⅝,	⅞	—	—
Do. 1st Preference	9½,	9¾	9⅝	9⅜
Western Brazilian	7¼,	7½	7⅜	7 5-16
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¾,	⅞	⅞	13-16
Oriental	3-16,	5-16	—	—
United Telephone	13,	13½	13½	12½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	2½	—
Do. (fully paid)	3¾,	4½	4	—
Swan	1⅜,	1⅝	1½	1⅜
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	36½	36
India Rubber, Gutta Percha, and Telegraph Works	22	23	22½	—

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NOTES.

ROUBAIX.—The town of Roubaix (Belgium) is to be provided with a central station for electric lighting.

THE WEST INDIES.—Telegraphic communication with all the West Indian Islands, and with British Guiana, is now restored.

TANGIERS.—A telephone exchange has been opened at Tangiers as a private enterprise, and is in the hands of some Spaniards.

POST OFFICE TELEGRAPHS.—Mr. W. Nisbet, assistant-telegraph superintendent at Glasgow, has been appointed to the postmastership of Inverness.

"CHEMISTRY FOR BEGINNERS."—We have received a copy of "Chemistry for Beginners," by Mr. R. L. Taylor, F.I.C., F.C.E., which is published by Messrs. Sampson Low, Marston and Co.

"FACTORY ACCOUNTS."—We have received from Messrs. Crosby Lockwood and Co. a copy of "Factory Accounts: their Principles and Practice," by Mr. Emile Garcke (of the Anglo-American Brush Electric Light Corporation) and Mr. J. M. Fells.

PARIS.—It is stated that the Odéon Theatre at Paris is to be lit throughout by electricity. We fear, however, if the regulations recently issued by the Paris police are to be scrupulously observed, that this will prove a somewhat costly installation.

TELEPHONIC CONCERT AT SUNDERLAND.—At a Workmen's Exhibition at Sunderland a very successful telephonic concert was organised, the performers being at Newcastle and Middlesborough. Loud-speaking telephones were used, and the songs and music were distinctly heard by a large audience.

THE LIGHTING OF BUCHAREST: TENDERS WANTED.—The question of the public lighting of the city of Bucharest has been for some time under discussion, and it is now stated that plans and estimates are invited from foreign firms. Information may be obtained from the office of the Mayor (M. Jean Campineano).

NEW METHOD OF REGULATION IN THREE-WIRE DISTRIBUTION.—Prof. Elihu Thomson has recently devised an ingenious method of equalising the potential on the two halves of a circuit worked by the three-wire system. Unfortunately, the pressure upon our space this week compels us to hold over a description of the apparatus.

"THE FINSBURY TECHNICAL COLLEGE MAGAZINE."—The April number of this admirable little journal is just to hand, and contains a very capital portrait of Silvanus P. Thompson. As usual, the letter-press is excellent, and we congratulate both the editor and the Finsbury College students on the success of their literary venture.

THE COLONIAL CONFERENCE.—At the meeting of the Colonial Conference held on Wednesday last, the discussion on telegraph and postal matters was resumed. Mr. J. Pender and the Hon. H. Finch-Hatton gave evidence on the subject of the existing and proposed lines of submarine cables. The discussion was adjourned to a subsequent meeting.

ELECTRICITY AS A MOTIVE POWER.—We have received a copy of an interesting pamphlet issued by Messrs. Stephens, Smith and Co., of Millwall, entitled "Electricity as a Motive Power, with Special Reference to its Adaptability for Marine Propulsion." Messrs. Stephens, Smith and Co. were the builders of the electric launch "Volta," which crossed the Channel last summer.

PENNY SCIENCE LECTURES AT THE "VIC."—The syllabus of the Penny Science Lectures, which are now being delivered on Tuesday evenings at the Royal Victoria Hall and Coffee Tavern in the Waterloo Bridge-road, contains a lecture by Dr. J. A. Fleming, on May 10th, on "The Ice Rivers of Switzerland," and one on May 17th, by Mr. Wm. Lant Carpenter, on "The Electric Telegraph and its Jubilee."

THE PARIS-BRUSSELS TELEPHONE LINE.—The French and Belgian Governments have concluded an additional convention with regard to their international telephone line. A tariff has been drawn up, based on a monthly subscription for the use of the line for periods varying from 10 minutes up to 80 minutes at a time, with a prescribed interval between each conversation. The subscription varies from 100fr. for 10 minutes up to 600fr. for the maximum period.

THE LIGHTING OF THEATRES.—From statistics recently published it appears that during the last two or three years there has been a notable diminution in the number of theatres destroyed by fire. In 1884 there were twenty-five catastrophes of this character; last year there were only eight, of which the greater number (how many we do not find stated) were set down as due to gas. The total loss of life from this cause during the last twelve months closely approached 100.

A RASH BET.—We have the authority of a local journal for the statement that some time ago the present Mayor of Blackpool, who was at one time exceedingly sceptical as to the success of Mr. Holroyd Smith's electric tramway, went so far as to bet Mr. Bickerstaffe, who is, we believe, one of the directors, a champagne supper that the concern would shut up in less than two year's time. As the company is already paying a respectable dividend, this looks uncommonly like a lose for his worship the mayor.

A FARMHOUSE STRUCK BY LIGHTNING.—The farmhouse of Mr. Thomas Atley, at Thornborough, near Thirsk, was on Saturday afternoon struck by lightning, and partly unroofed. The discharge passed through the house, smashed the windows, and injured two daughters and a son. The full extent of the injuries is not precisely known. A later account states that the house was unroofed on the east side, and two rooms, together with their contents, were wrecked. Miss Annie Atley was burned on her left arm, but the other inmates sustained but little injury. Some poultry were killed near the house. Nine sheep were killed on the farm of Viscountess Downe, at Baldersby Park, Thirsk, during the storm.

THE AGRICULTURAL ENGINEERS' ASSOCIATION.—We have received a letter from Mr. Henry D. Marshall, the president of the Agricultural Engineers' Association, from which we learn with regret that at the forthcoming show of the Royal Agricultural Society at Newcastle this association will not enter any engines in competition for the prizes offered for agricultural locomotives. The action of the association, which seems to be endorsed by all the leading makers of this class of machinery, is based upon their opinion that sufficient notice has not been given of the intention of the Society to award such prizes; neither has the Society permitted them to have any voice in framing the conditions under which the trials are to be carried out.

ELECTRIC LIGHTING IN THE FRENCH PROVINCES.—It is believed that the following is a tolerably complete list of the towns in which electric lighting from central stations is at present in operation in the French provinces:—Lyons, Rheims, Marseilles, Tours, St. Etienne, Angers, Bourganeuf, Domfront, and Chateaulin. To these may be added Dijon, where a central

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station, working on the parallel system, was not long since in successful operation, but which has been stopped for the time being, pending a change to the transformer system. This has been rendered necessary owing to the complaints which were made by the occupants of the houses near the central station. The machines are now to be removed to the outskirts of the town.

ELECTRIC LIGHT AT THE WINTER PALACE, ST. PETERSBURG.—The Czar of Russia, at his Winter Palace on the banks of the Neva, possesses what is probably the largest permanent installation of electric light ever placed in a single building. The palace itself is illuminated by 12,000 incandescent lamps, while 56 powerful arcs light up the front and the various court-yards. The machine room contains eight engines, capable of developing 2,500 horse-power; the dynamos, including reserve machines, are 26 in number. The work was planned and carried out by the engineers of the palace, in conjunction with the St. Petersburg House of Siemens and Halske, and the installation has been at work since the commencement of last winter.

FOLKESTONE.—At a recent meeting of the Town Council at Folkestone it was remarked that Hastings, Brighton, and Eastbourne having gone in for the electric light it had become a question whether they ought not to make a move in the same direction at Folkestone. This reasonable suggestion was, however, promptly "sat upon" by the mayor, who said that when he was at Hastings the other day he could not help remarking that the part of the town still lit with gas not only looked much nicer, but was really much better lighted. It was true (his worship had the candour to add) that he happened to have a few gas shares, but that fact did not even present itself to his recollection at the time, while he remained lost in admiration of the Hastings gas lamps.

"PRACTICAL ELECTRIC LIGHTING."—"Practical Electric Lighting," by Mr. A. Bromley Holmes, is one of the best books of its class with which we are acquainted. Without attempting to rank as a scientific treatise, it contains just that amount and kind of information with which the owner of an electric light installation, or any non-scientific man who is brought into contact with such an installation, will wish to become acquainted. The third edition has now made its appearance, and has undergone some alteration and enlargement from the previous issues. In future editions we would, however, suggest that Mr. Holmes would do well to make room for such new matter as he may consider desirable by cutting out a certain amount of space devoted to the description of obsolete apparatus.

AN EARLY REFERENCE TO VARIABLE PRESSURE CONTACTS.—Mr. A. M. Tanner, writing to the *Electrical World* of New York, says:—"In *Poggendorf's Annalen*, Vol. III., for the year 1860, appears an article by Beetz on the electrical conductivity of different bodies. The article states that platinum sponge is closely packed in a narrow tube, and that conducting wires are passed into the ends of said tube. These wires are movable, so that when they are pressed together the galvanometer shows an increase of current. It is evident that Beetz gives the results of practical experiments, and he even goes on to say that the conductivity of the platinum sponge is increased when heated, and that the latter effect is produced when the wires are pressed together." Clerac has hitherto been generally regarded as the first observer of the variation of electrical conductivity by pressure.

THE VAN GESTEL STORAGE CELL.—Mr. J. J. Van Gestel, of New York, has designed a storage cell which is intended more particularly for use in lighting railway carriages and for tramcar propulsion. He takes a lead-covered copper wire (the wire being *un*-insulated), surrounds this with a lead tube of considerably larger diameter, and fills the space between the tube and the wire with red lead. This compound cylinder is then bent round several times upon itself so as to form a flat rectangular spiral. The plates so formed are perforated with numerous holes, and crushed glass is placed within the cell to prevent the spilling of the liquid. Special machinery has been designed for the manufacture of the plates, and the compound tube can be turned out complete, ready to be coiled up, at the rate of 2,000ft. per hour.

MANCHESTER ROYAL JUBILEE EXHIBITION, 1887.—At the Manchester Jubilee Exhibition the distance of the fine art galleries and of old Manchester and Salford from the dynamo room is very considerable, in the former case about a fifth of a mile, and in the latter a quarter of a mile, and the very large number of lamps required has necessitated the employment of exceptionally heavy conducting wires formed into cable for the incandescent lighting of these sections. These cables have been made in various sizes, according to the requirements of the several sections, but they represent a total length of cable exceeding nine miles, whilst the bare weight of the copper alone required for the conductors is very nearly ten tons. The whole of the conducting wires, mains, branches, and leads, for the incandescent lighting, and also the major portion for the arc lighting of the Royal Jubilee Exhibition, have been manufactured and supplied by Messrs. Walter T. Glover and Co., of Salford.

THE SCHOOL OF ELECTRICAL ENGINEERING, HANOVER-SQUARE.—The well-known establishment in Hanover-square, of which Mr. William Lant Carpenter is Principal, has recently enlarged its educational resources by the addition of a boiler and steam engine, built specially for purposes of instruction, and for illustrating the lectures on mechanical engineering. The five dynamo machines previously in use can now be driven either from the new engine or from the old gas engine, and provision is made for taking accurate mechanical as well as electrical tests. Mr. Carpenter is undoubtedly well advised in bestowing increased attention upon this side of the training of the young electrical engineer, who in the past has, it must be confessed, sometimes been found wanting in mechanical knowledge and skill. At a recent visit to the school we noted also with pleasure that lathes and other workshop tools had been added. The electrical equipment has also been rendered more complete by the addition of a battery room, containing a large number of E.P.S. cells, and provided with every facility for their testing and manipulation.

THE ELECTRIC SIREN.—According to statements which have recently been made in the daily papers, it appears that at Cape d'Ailly, where the wreck of the "Victoria" took place, the steam siren cannot be brought into action in less than an hour. This statement, if true, shows an urgent need for some improved method of working these apparatus. Fortunately, the means are already at hand. Let the siren itself be driven by an electric motor, supplied by a set of accumulators; the latter being charged from time to time by means of the engine and boilers already in use. The engine would be used for filling the reservoir of compressed air as at present. The siren can then be set to work at any time without a moment's delay. We note that one of the French technical journals, while making a similar suggestion, goes a step further, and proposes to make use of the electro-magnetic siren, which consists of an iron disc pierced with numerous holes, and rotated before the poles of a powerful electro-magnet. We are, how-

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ever doubtful whether the tones of this instrument can be made to rival the strident blast of the apparatus now in use.

SOME PLATITUDES.—Some time ago we had occasion to remark that the final temperature of a conductor traversed by a current is not equiualent to that due to the quantity of heat generated therein in *one* second, and further, that if a current of 2,642 amperes traverses a resistance of ·035 ohm, it cannot be right to assume that there is no loss of potential on the line. It seemed necessary to mention the fact that these assumptions are incorrect, simply because they had been adopted in an American technical work—in other respects a book of considerable value and importance—which we had then under review. Mr. T. W. Rae, who is responsible for the calculations in question, has written at some length to the *Electrical World* of New York in support of the views which he still maintains. We subjoin an extract from this letter, in which, however, the italics are our own, and can only express our regret that the pressure upon our space does not permit us to argue the question further with Mr. Rae:—"Enough algebra," says Mr. Rae, "has drifted to this side of the Atlantic to enable even American electricians to comprehend that while a current in a conductor, considered as a static charge, is uniform at every point, yet its rate of performing work at any point is directly proportional to the potential there, which in turn bears a ratio to the resistance between the point and the origin of current. *Experience does not yet indicate where this property begins to make itself felt prejudicially.* In railway conductors of over four miles circuit, which have been in daily use for eighteen months, the difference of potential at the remote point is practically inappreciable in the regular working of the line. A knowledge of such instances might tend to modify the tone of the reviewer." Nevertheless, if we may say so without discourtesy, we would add that we confidently expect to see Mr. Rae's figures amended in a second edition of the work in question.

THE SCHANSCHIEFF BATTERY FOR MINERS' LAMPS.—At a general meeting of the members of the North of England Institute of Mining and Mechanical Engineers, held on Saturday last at Newcastle, under the presidency of Sir I. Lothian Bell, a paper was read by Mr. S. B. Coxon, describing an "Improved electric safety lamp, with Schanschieff's primary single liquid battery." The author stated that a primary battery had some disadvantages compared with a secondary one; but he thought it might safely be predicted that those disadvantages would disappear in practice. The new single liquid battery of Schanschieff offered great advantages over those hitherto in use, as being a single fluid. The solution was kept confined, and could not escape or leak out of the battery. The lamp, complete, was so simple that the top could be taken off and the battery emptied and charged by any person, although he might be without any knowledge of electricity. When once charged the lamp could be kept for any length of time with the elements above the solution, and be ready for use in a moment by simply turning the elements into solution. The advantages claimed for the lamp were that the E.M.F. was perfectly constant; that the internal resistance was very small, only ·03 ohm; that it gave a perfectly steady current, and no polarisation was possible; that it was quiescent when the current was open, and that it was cheap and durable. Mr. Schanschieff was present, and exhibited three lamps, each of different size. The small lamp, he said, gave a light equal to about two candles for eight hours, and the large lamp a light equal to four or five candles. The cost of maintenance would, he thought, be 1d. or 1½d. per shift. He had an arrangement to detect marsh gas in his lamp; but he could not explain it until he had secured the patent. He hoped to be able to show at their next meeting the arrangement attached to one of his lamps. A vote of thanks was passed to Mr. Schanschieff.

ELECTRIC LIGHTING AT A WOOL FACTORY.—The Woodhouse and Rawson Contract and Maintenance Company have recently completed an installation of electric lighting at the works of Messrs. Campbell and Harrison, wool combers, Bowling. The works comprise two three-story warehouses, the offices, and four very large sheds, in which there are forty Noble's combs, fifty carding machines, and the necessary wool-washing, drying, and preparing machinery, besides mechanics' and joiners' shops, comb setting and brush-making departments, engine rooms, boiler house, &c. As operations are carried on continuously night and day, except Sundays, the lighting is a matter of the first importance. Altogether there are about 400 incandescent lamps distributed over the premises. To supply the current for these there are four Mather and Platt dynamos, three of which are used for lighting direct and one for the charging of a small storage battery, consisting of 26 E.P.S. cells. But as the object aimed at in designing the installation has been to render a breakdown, even of a temporary character, as nearly as may be absolutely impossible, the dynamos laid down have a collective capacity equal to carrying over 800 lamps. Power is supplied by one of either of the two main engines—a beam engine and a compound horizontal condensing engine—used for driving the works, either engine being powerful enough to carry the whole concern comfortably. But assurance against a breakdown in this respect is rendered doubly sure by an ingenious arrangement of the shafting used for driving the dynamos. The shaft from which these are driven is cut into four sections, which are coupled end to end by three claw clutches; and at the end of the driving shaft opposite to that at which it is driven by one of the main engines is a small subsidiary high-speed engine of 30 horse-power, by Messrs. John Fowler, of Leeds, and is fitted with Hartnell's automatic expansion gear; this engine alone is capable, upon an emergency, or during the stoppage of the main engine at meal times, of carrying the major part of the installation. The largest of the four dynamos is alone capable of carrying over 300 lights, but the machines are so arranged that the whole work may be undertaken by this machine, or distributed at will. Each of the four dynamos is governed by a main switch, placed upon a slate switch-board in the dynamo room, and the switch-board is so arranged that any combination of circuits may be switched on to any of the dynamos or combinations of them. Each of the four circuits carries about 100 lamps, and is protected by one of Woodhouse and Rawson's magnetic cut-outs. There is a second and smaller switch-board for the storage batteries, also provided with cut-outs. In addition to lighting the premises, the dynamos supply current for actuating a small electric motor used for working an electric tramway for conveying wool from one end of the premises to the other. In the dynamo-room there are placed a voltmeter and an ammeter, which may be switched on to any one of the circuits at pleasure. Messrs. Campbell and Harrison state that not only does the use of electric lighting enable them to effect a considerable economy as compared with the use of gas, but that a reduction of the temperature in the sheds of from 15° to 20° has followed, resulting in the greatly improved health and comfort of their workpeople, and also in the better quality of the work performed.

"HOW TO MAKE A POCKET ACCUMULATOR."—We quote the following interesting note from the *Finsbury Technical College Magazine* for the present month, where it appears

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over the initials "R. L. D.":—"There are several kinds of pocket accumulators in existence. There is the thick one, whose box is made of ebonite, the thin one made with lead casing, and the thin one made of ebonite. Of these the last is the most convenient and portable. The ebonite box, with the accompanying top, may be obtained very cheaply. The boxes are made with a partition down the middle to form two cells. The first step is either to shellac varnish or cover with elastic glue the edges of the partition, to make it water-tight; the next is to make the plates. The simplest plan is to get a plate of lead about 1-12th of an inch thick, and cut it up into six strips just broad enough (say 1in.) to go into the cells, three in each, side by side. The usual length for these strips is about three inches, depending on circumstances. Each of these strips should be made with a lug at one end to project outside the cell. The top of ebonite is then divided into two, and each half carefully fitted into the inside of each cell. Each half then has three holes cut in it for the lugs to come through, and a hole through which to pour the acid into the cells. The six strips are then placed in position, three in each cell, with two india rubber bands passed round the middle strip of each cell; the band should go round vertically, not horizontally. This will be sufficient to insulate them from each other. A band may be placed round all three, if preferred, to steady them, but is not necessary. The tops are then put in and glued in carefully, taking great care that no hole is left where leakage might occur, either from one cell into the other or from the cells to outside. There are then six lugs of lead projecting out from this, three in one half and three in the other. The two outer lugs of one cell are then joined to the inner lug of the other cell; the inner lug of the first cell is fixed into a binding screw, which is then vertically fixed into that end of the top, and the two outer lugs of the second are fixed to another binding screw, which is then fixed in a similar manner to the former in the other half of the top. A small glass tube about ¾in. long is then placed in each of the two remaining holes. A layer of glue is then put all over this, so that the only parts projecting are the binding screws and the tops of the two glass tubes. The binding screw, which is connected with the centre plate of the first cell, is then marked + and the other −, as the centre plates in each cell will be the + plates. Acid is then run into the cells, the proportion of acid to water being 1 in 6. The cells are then charged, discharged, and reversed a large number of times till fit for use. When used in the pocket, the glass tubes should be closed with gutta percha stoppers. The accumulator may be used before the plates are fully formed, but the forming process should continue till the plates have a capacity of about two ampere hours. The E.M.F. of these cells is four volts. It is advisable to make a case of some sort for the accumulator, in case there should be any slight leakage of acid, which would otherwise have disastrous consequences on the wearer's clothes. Of course these cells will not stand much rough treatment, but must be used carefully. The total cost, when made in the way described, is very small, only amounting to a few shillings."

Dangerous Electromotive Forces.—In a communication by M. d'Arsonval, lately read before the Société de Biologie, entitled "De la mort par l'electricite," the author draws a distinction between the physiological effects of discharges of static electricity, of "the extra current," and of alternating currents. In the latter cases there is no lesion of the vessels, and the subject may often be recalled to life by setting up artificial respiration; this treatment should be immediately adopted in every case of apparent death from an electric shock. Static discharges, on the contrary, in case of serious injury, effect a complete disorganisation of the tissues, which renders remedial measures hopeless. We are not aware whether any explanation of the difference thus established has yet been given; the following explanation, however, readily suggests itself. When the body forms a portion of a closed circuit, no matter how great the E.M.F. may become, the current will presumably be distributed throughout the body in accordance with the ordinary laws of conduction. On the other hand, if the body receives a static discharge of high tension, it is permissible to assume that at least the greater part of the discharge takes place in a comparatively narrow path, which will have been previously marked out by polarisation along the lines of least resistance. If, then, the resistance of the blood be less than that of bone, muscle, tendons, &c., the discharge would take place chiefly along the lines of arteries and veins, and the sudden distension of the liquid with which it would be accompanied would account for the rupture of these vessels. M. d'Arsonval is inclined at present to put 500 volts as the inferior limit of a dangerous E.M.F. for continuous currents. For alternating currents the author thinks that 60 volts should be the maximum; how he arrives at such a low figure as this is not clearly explained. On this point it is a noteworthy fact that no less an authority than Professor Elihu Thomson has recently expressed the deliberate opinion that, under high tension, alternating currents are positively safer than the so-called continuous currents. The Professor is entitled to speak with authority upon this point, for not only has he made a special study of high tension currents, both continuous and alternating, but he has also twice over received a "shock" from a machine of the latter class. The potential of the conductor with which he came in contact in one case exceeded 1,300 volts, and in the second was believed to have been considerably higher than this; yet in neither case did any "organic lesion" ensue, and, in fact, with the exception of a slight blister on one finger, the Professor assures us that he felt none the worse. What does M. d'Arsonval make of this? It is, of course, permissible to suggest that Prof. Thomson may be endowed with some remarkable and special power of resisting the effects of an electric shock; at any rate, until proof has been given to the contrary, we confess that we are so far impressed with the justice of M. d'Arsonval's case that we should certainly hesitate to attempt a repetition of the Professor's exploits in our own person. The theoretical reason advanced by Prof. Thomson for believing that alternating currents are in reality less dangerous than continuous currents is that high tension continuous current dynamos never yield absolutely continuous currents; on the contrary, their currents are subject to abrupt and continuous fluctuations or jerks, which may give rise to shocks more severe, and physiologically more dangerous, than the rhythmic undulations of an alternating current. The same reason accounts for the observed fact that an alternating current is a far less annoying neighbour to a telephone line than an arc-lighting current. In the one case a musical note is heard in the telephone which interferes very little with conversation. In the other case a continual strident sputter is set up making conversation impossible. We shall hope to hear that M. d'Arsonval continues his difficult and to some extent perilous investigations, but after what has been said in America he will no doubt find it desirable to reconsider his limit for alternating currents. In fact, what is wanted is not the arbitrary assumption of some particular figure, but a careful and as far as possible an experimental determination of the actual conditions under which a current becomes a source of personal danger.

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INCANDESCENT LAMP MANUFACTURE.—XIV.

BY J. SWINBURNE.

Glassblowing.

Glassblowing in lampmaking consists of three processes; making the stems, making the bulb, and sealing the mounted carbon into the bulb. Stems are not always used, as most makers prefer to attach the carbon to two pieces of platinum wire and to seal them into the bulb. The writer prefers the old method, as, unless made with very great care, the wires are apt to be sealed in unevenly, and the lamps look badly finished. If the platinum wires are to have sockets the sockets are made first. If the glassblowing is done without the aid of machinery, a quantity of glass rod and glass tube is cut up into pieces about ¾in. long. The tube is about three-sixteenths of an inch outside, and the rod is small enough to pass into it loosely. A piece of the rod is heated in the blow-pipe until soft, and the platinum wires are stuck to it in their proper position, a piece of tube is then slipped over them and the whole is heated till the tube is fused round the wires and rod. When the stem is cold the wires are bent into their proper shape. The eyes are made when the stem is sealed in. The stems can be made much more quickly by a special machine. This is a little lathe, and is a modification of Messrs. Wright and Mackie's well-known machine. The platinum wires are cut to the right lengths, and the ends are bent round to form eyes. The two platinums are held between two jaws, which have little recesses, so that the wires are held at the right distance apart. The platinums are then revolved while the blow-pipe plays upon them, and the operator holds a piece of glass rod in the flame, so that as it fuses the glass is wound on the platinum wires. If necessary, a little arsenic enamel is put round the part where the stem will be joined to the bulb. This process is very quick, as a girl can make 300 per day. The stems are also better, as the glass is not so likely to crack along parallel to the platinum, as it often does in stems made by slipping glass tubes over rod. The writer's apparatus for bending the platinum wires to the right shape so as to make them fit the mounting machine is shown in Fig. 10. It consists of a brass base, which is a

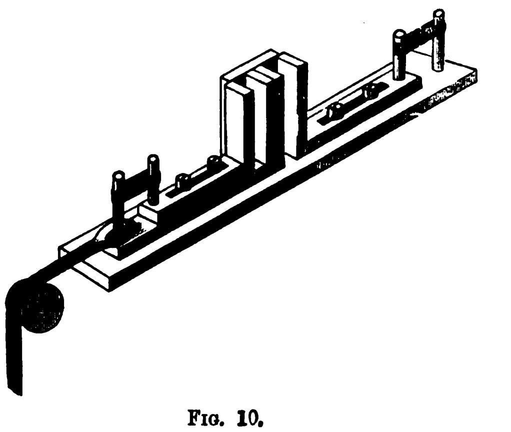

FIG. 10.

strip with a vertical strip sticking up. An angle piece slides on this so as to form a jaw, as shown to the right. On the left another angle piece, with a smaller angle piece mounted on it, forms the second pair of jaws. An india rubber band is put over each pair of pins, so as to keep each pair of jaws open as shown, and a third band, not shown, is put over the two outside pins so as to keep the pairs of jaws together. The operator takes a stem and puts the wires in the open jaws; the plate at the back regulates the distance. She then takes hold of the outer jaws with her finger and thumb, thus closing them on the wires. She then presses a treadle which is attached to the pair of jaws shown to the left, and this pulls the pair of jaws apart till the wires are bent exactly the amount needed. She removes her thumb and finger, and the jaws open, and the stem is taken out. On raising the treadle the jaws return ready for another stem. This bends the wires very evenly and quickly.

The bulbs of lamps are blown out of glass tube, or made direct from melted glass at the glass works, in the same way as wine glasses are made, or else they are made by blowing glass into moulds according to Mr. Alfred Swan's method. The bulbs may be blown from English or German glass. English or lead glass softens more quickly and more suddenly than German; but unless carefully worked it is apt to blacken. It must always be worked in the oxidising flame of the blow-pipe. If English glass blowers are employed, it is best to use lead glass, as they are accustomed to it, but Germans can, as a rule, only work with their own glass. It is generally easier to get a German workman to work with lead glass than to persuade an English glass-blower to try to use German glass. It is generally necessary to teach girls or boys to do the glass-blowing, as glass blowers are expensive and unmanageable, and it is best for that reason to use German glass. It is easier to work, but it does not look so well in the finished lamp. The process of blowing the bulb need hardly be explained here, as it has often been described in print and shown in public. Major-General Webber's Society of Arts paper was published in *The Electrician* of last December, and it contains drawings and descriptions. Anyone who wishes to teach himself the elements of glass-blowing will find a little book by Mr. Shenstone, of Clifton College, published by Macmillan, very useful. The price is eighteenpence.

Blown bulbs should not be stored for a long time, as a film of gas condenses on the surface, and the longer the bulbs are stored the more difficult it is to remove this film on the pumps. Bulbs should also always be made with their tubes sealed up, so that dust does not get in. Sometimes bulbs have a sort of mottled deposit on the inside of the glass; this is very difficult to get off. It seems to be due to the human breath used in blowing the bulbs, and seems to be worst when the glass blowers are Germans, perhaps because they smoke more. Unless the glass blowers are very carefully watched, they will get into two bad habits. They will make the thin neck of the bulb, where it is to be sealed off, too large in the bore, or too thin in the wall, so that when the lamp is sealed on the pump, the tube folds in or even bursts inwards. The exhaust tube should be very small inside, and should have very thick walls, so that when it is sealed it forms a solid nose. Nothing spoils the look of the lamp more than a bad nose, and a nose sealed in thin tube not only frequently cracks and spoils the lamp, but is broken off by the least knock. The nose should be quite short. The other habit is making the sealing on tube too thin in the wall. This makes it difficult to seal them on to the pumps, as the pump tubes have thick walls. The glass should be run together a little before drawing out. Both these faults are due to laziness on the part of the glass blowers. Some makers give up attempting to make the glass blowers make thick enough sealing-on tubes, and have separate pieces of quill attached.

The process of blowing bulbs direct from molten glass need not be described, as it is never carried on in the lamp factory. Mr. Alfred Swan's process makes very good bulbs, but it is a secret, and so cannot be described here. The writer much prefers to make bulbs, and, in fact, to do most of the glass blowing by Messrs. Wright and Mackie's machines. These were fully described and illustrated in 1883. The writer has had considerable experience with them. It is necessary to have a man or an intelligent lad who can teach the others to use the machines. The machines, as at present arranged, are a little wasteful of glass, as the tube has to be cut up into pieces about ten inches long, each piece making two bulbs. There is no reason why a machine should not have its mandrels long enough to take long pieces of tube. A piece would then be put in each mandrel, and the ends would be sealed together and drawn out into a double neck, so as to serve as sealing tubes for both bulbs. Two bulbs would then be blown and removed. The tubes would then be pushed out a little further and the process repeated. Though the waste of glass is greater with these machines than it might be, it is less than when the bulbs are blown by hand, and when it is remembered that the work is done by girls at low wages the whole saving is very great. Instead of the blow-

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pipe originally on the machine the writer uses Fletcher's larger automaton blowpipe. A spiral spring is attached to the pin that works the regulating plug, so that when the operator takes her hand off the flame is reduced till there is just enough to keep the blowpipe alight. This saves a great deal of waste, as it is impossible to get people to realise the importance of apparently small economies.

The sealing in is generally done now by squeezing the glass over the platinum wires. The carbon is fixed to the wires, which may or may not have a little bridge of glass melted on to keep them at the right distance apart. The bulb is held by the sealing tube, and the other tube is opened and the carbon put right inside the bulb. The tube is then drawn down to a neck, about a quarter of an inch in diameter, and cut off. The carbon is then allowed to come back till the platinum wires project, and the glass is squeezed over them, and the bulb blown into a little to give the end a good shape. The chief advantage of this form is that it allows vitrite or other caps to be fixed on more firmly. If the platinum wires are sealed into glass stems, the glass stems with the carbons are put right into the bulbs as before, and the process is the same except that the glass is not squeezed. Before the sealing is finished the ends of the platinum wires which stick out are turned round into eyes and stuck into the glass again. A little glass is sometimes dabbed on to hold the wires more tightly. It is better to make the stems on the lathe from melted rod, as already described, and to turn the platinum wires into eyes with a good length of wire turned back, so that the glass is melted over about a quarter of an inch of return wire. Stems made this way are more troublesome to seal in, as the mass of glass is large, and they have to be drawn back from the bulb without the tube being made very narrow. The seal is further apt to crack if not carefully annealed, but when made well this method makes far the strongest loops. When unskilled glassblowers seal in they can work best with an india rubber tube with a mouthpiece, so that they can blow into the bulbs without moving them up to their mouths and into a position in which they cannot see what they are doing. Sealing in is also done on the Wright and Mackie lathes; it is then very easy. The stem with the carbon is fixed in jaws on one mandrel, and the bulb is fixed in the other. The carbon is run up into the bulb, and both are rotated together in the flame of the blowpipe till the glass is fused solid to the stem. The jaws are then opened and the mandrel moved out of the way, and the end is blown out a little to thin the glass. The glass is apt to be a little thick, which makes the lamp liable to crack, and it is often advisable to run a little arsenic enamel round the end of the stem to prevent this. Enamel prevents cracking, because it has a lower melting point than glass, and thus avoids the strain due to the uneven contraction of a large mass of glass cooling unequally. The glass blowers should be able to make the pumps and other glass work used in the factory. Sprengel pumps cannot be made except by skilled workmen, and flashing flasks are difficult to blow. It would be best to have one or two good glass blowers to do the skilled work and to teach the others; but, unfortunately, glass blowers are difficult to manage. They think that if they do not teach your beginners you will have to employ them and give them the high wages they demand, and let them keep the irregular hours they prefer. It is therefore necessary to be quite independent of them, and, if possible, not to employ them at all. The writer has worked a factory without a single trained glass blower, and all the pumps were made there. The flashing flasks were got outside, because the machines would not take large enough glass tubes. This demands a great deal of personal supervision. It is often necessary to keep the work of each operator separate, from the glass blower's room to the test room, so that when the lamps crack through bad annealing the fault can be traced, otherwise carelessness will creep in, especially if the glass work is done "on piece."

The stems must be made of lead glass, or they will crack. If the carbons are sealed in without stems by squeezing the glass over the wires, the bulbs must, of course, be made of lead glass. The writer prefers to use German glass for everything except stems. Above all, samples of various kinds of glass should not be got in to try and then allowed to mix with the stock glass. There is nothing more troublesome than to get the glass mixed.

ON REGULATING SERIES-WOUND TRANSFORMERS.

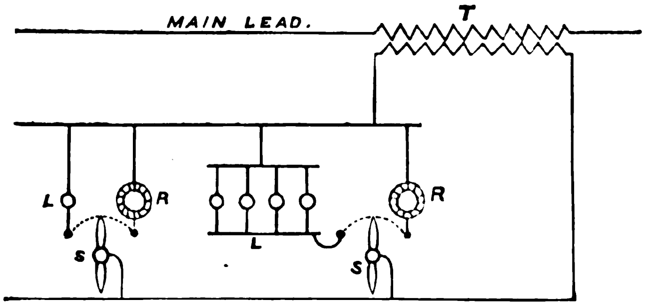
It is now a well-known though perhaps a somewhat unfortunate fact that transformers of the ordinary type of construction, when used in the ordinary way, only yield constant difference of potential in the secondary circuit if supplied with current under the same condition in the primary. We say unfortunate, because the inherent defect of parallel working is not entirely obviated by the use of the transformer, and however high may be the E.M.F. employed, it is physically impossible to secure absolute constancy of potential in the mains. This objection has, we believe, already made itself felt in some of the installations already at work. A constant-current system, if once the question of regulation is solved, not only avoids this difficulty, but it presents some other obvious advantages; both mains and transformers should, for instance, be cheaper to construct, and the potentials at the terminals of the primary coils would be lower. On the other hand, it is necessary to remark that the arrangements for working the alternating machines at a large central station present less difficulty under a constant potential than under a constant current service. In the former case, as the demand for current varies, machines can readily be cut out or added in parallel, while, as is well known, alternating-current dynamos are not capable of working together in series. Coming now to the kernel of the question: Can a series transformer be made self-regulating, and, if so, can it be done consistently with economical principles?

Experiment, in the hands of Mr. Rankin Kennedy (to speak only of one of its earliest exponents), says "No." Recent theoretical investigation, due to Mr. Kapp, has indicated the limits within which such a result can be approached, pointing out, however, that the conditions are not those of practice. Painful experience at the Grosvenor Gallery and elsewhere has emphasised the fact that no attempt to get round the difficulty by mechanical adjustment of the core (so as to vary the magnetic resistance) can possibly afford a practicable solution. There remain, however, at least two distinct directions in which it may still be open to question whether a solution is not yet attainable. One such method would consist in the application of some subsidiary regulating apparatus whose function should be purely electrical, and therefore automatic (any mechanical device may at once be ruled out of court). A second, and a better solution, would be to hit upon some new principle of construction capable of directly fulfilling the required condition. Doubtless many electricians have been working on these lines, and it is satisfactory to be enabled to announce that perfect success has already attended the efforts which have been made in each of these directions, although for the present we are only in a position to publish details relating to the first-named method.

It is now some months ago, that, at the invitation of Messrs. Sharp and Kent, of Westminster, we had the pleasure of witnessing the performance of an ingenious device, producing perfect self-regulation in the secondary circuit of a 2 horse-power Gaulard-Gibbs transformer, under the condition of constant mean current in the primary coil. The apparatus is extremely simple and purely automatic in action, and, further, as will presently be shown, the energy consumed in regulation is really negligible. The device consists in providing for each lamp (or for each group of lamps which are turned on or off together) a small resistance coil wound with wire to carry the same current as the lamp, and so proportioned that the virtual resistance of the coil is equivalent to the actual resistance of the lamp—in other words, the resistance and self-induction of the coil are such that, if a lamp in any branch be replaced by a coil, the current flowing through that branch of the circuit will remain unaltered. The dimensions of the core (which takes the form of a closed ring) and the number of windings have therefore to be determined with reference both to the periodic time of the current and to

the E.M.F. of the lamps. This being understood, it is easy to see that if each lamp or group of lamps is provided with such a coil, and the connections are made so that the act of switching off a lamp switches on the coil in its place, as shown in the figure, then the current through the secondary remaining unaltered, so also will the mean difference of potential at the terminals of the remaining lamps, there being nothing, in fact, to upset it. It will be noticed that the coils are entirely out of circuit so long as the lamps with which they are connected are in use. In practice the regulation so obtained is perfect. We found that when 10 lamps out of 12 were switched off the Gaulard-Gibbs (series-wound) transformer *without* using the coils, the Cardew voltmeter indicated a rise of E.M.F. of nearly 20 per cent., while with the coils in use it was impossible to detect any variation.

It remains to show that the energy expended in the coil which replaces the lamp is in reality quite trifling in amount. At first sight—especially to the student who is familiar only with continuous currents—it may be somewhat startling to assert that with mean values of E and I remaining absolutely constant, the energy expended in the circuit may be reduced to less than 1 per cent. of its initial value. Yet this enormous reduction is actually accomplished by Messrs. Sharp and Kent's induction ring; and the apparatus is thus well qualified to display some of the most interesting and important properties of alternating currents. The effect is, of course, due to the variation in the angle of retardation of the current over the impressed E.M.F. Now this angle—or rather its tangent—varies directly with L. the coefficient of self-induction, and inversely with the (actual) resistance R, so that when a coil, which has not only an enormously larger self-induction but also a very much smaller resistance, takes the place of a lamp, the lag is for both reasons increased, and the mean product of the *simultaneous* values of E and I is proportionately diminished.



T, series wound transformer; L, lamps; R, induction rings; S, two-way switch.

But further, it is obvious that the whole of the work actually done in the coil must appear as heat, and, neglecting the small loss due to hysteresis, this heat, in the coil, as in the lamp, is measured by the mean square of the current into the real or ohmic resistance. The currents being the same, the work done in the two cases is therefore proportionate to their respective resistances. Now, the ohmic resistance of the coil has to be determined chiefly by the value that must be given to the coefficient of self-induction in order to make its virtual resistance equal to the real resistance of the lamp. This can be found from the formula

$$S^2 = R^2 + (2 \pi n L)^2,$$

where S is the required virtual resistance, and n the number of alternations per second. If 100-volt 20 candle-powder lamps be used S will be about 160, and if n be 100, R will be negligible in this position, and the solution for L gives

$$L = \cdot 254.$$

Then, by properly proportioning the iron it is found perfectly easy to wind a coil to fulfil this condition which shall have a resistance not exceeding *one ohm.* If the periodic time be smaller, as it easily might be, then L, and consequently* R, would be still smaller.

But it has been already shown that the loss in regulation is expressed by the relative resistances of lamps and coils, which we now see to be as 1:160, and although to this something should no doubt be added on account of hysteresis, yet it certainly seems permissible to treat the loss as a negligible quantity.

We are not aware that Messrs. Sharp and Kent have made any actual measurement of the energy expended in the coils—which would, in fact, be somewhat difficult to determine with accuracy—but a rough and ready, though very practical, illustration of the saving of power was afforded by taking the governor off the engine and suddenly switching over from lamps to coils, with the result immediately apparent in the increased speed of the engine.

We have been much interested in these experiments, and cannot conclude our notice without expressing our admiration for the simplicity and ingenuity of the method. We shall perhaps shortly publish some further remarks on the theory of the action of the coils which, if followed out to its full extent, is in reality a little more complex than that here presented.

* A physical not a mathematical consequence.

ELECTRICAL MEASURING INSTRUMENTS.*

BY SIR WILLIAM THOMSON, F.R.S.

A fundamental requisite of a measuring instrument is that its application to make a measurement shall not alter the magnitude of the thing measured. When this condition is not fulfilled (as is essentially the case with an electric measuring instrument not kept permanently in or on the electric circuit or system to which it is applied), it is the magnitude, as influenced or modified by the measuring instrument, which is actually measured, and the measurement is to be interpreted on this understanding, whatever may be the circumstances. Suppose, for example, the thing to be measured is the diameter of a fine wire, or of the carbon filament for an Edison-Swan lamp, or of a hair, or of a silk fibre. If the measurement is made by a microscope with the proper optical apparatus for measurement, the thing measured is absolutely unaltered by the measuring appliance. But if its measurement is made by an ordinary screw gauge, or by any other mechanical fitting appliance, however gentle, it is impossible to avoid some diminution of the diameter to be measured by the pressure of the measuring appliance, which introduces some slight uncertainty even in the measurement of steel or copper wire, and very considerable uncertainty when a filament of softer material is to be measured.

The nearest approach in electric measuring instruments to the fulfilment of this condition, of not altering the magnitude of the thing measured, is attained by the electrometer when applied to measure differences of potential between different points of a wire or metallic mass of any shape in which electricity is kept flowing by a battery or dynamo or other electromotive apparatus. The insulation of any practical electrometer is so nearly perfect that the conduction of electricity through the instrument does not sensibly diminish the difference of potential of the points touched by the electrodes. In this respect, therefore, the electrometer would be ideally perfect; but, alas, it is only for potentials of more than 400 or 500 volts that the electrometer in any shape has been made a convenient and fairly accurate standard measuring instrument for ordinary practical use. For less than 400 volts the practical solution in connection with electric lighting is afforded by a current-measuring instrument with a known resistance in its circuit; though for many differential measurements, and particularly for measurements of the insulation of submarine cables and determination of the insulating quality of insulators for many practical purposes, the quadrant electrometer is found useful as a differential measuring instrument.

The quadrant electrometer in its most sensitive adjustment indicates about $\frac{1}{100}$th of a volt, and with modified adjustments (heterostatic and idiostatic) can be used for measuring up to 300 or 400 volts. It is described in detail in the

* "On a Double Chain of Electrical Measuring Instruments to Measure Currents from the Millionth of a Milliampere to a Thousand Amperes, and to Measure Potentials up to Forty Thousand Volts." Paper read before the Philosophical Society of Glasgow, April 20th, 1887.

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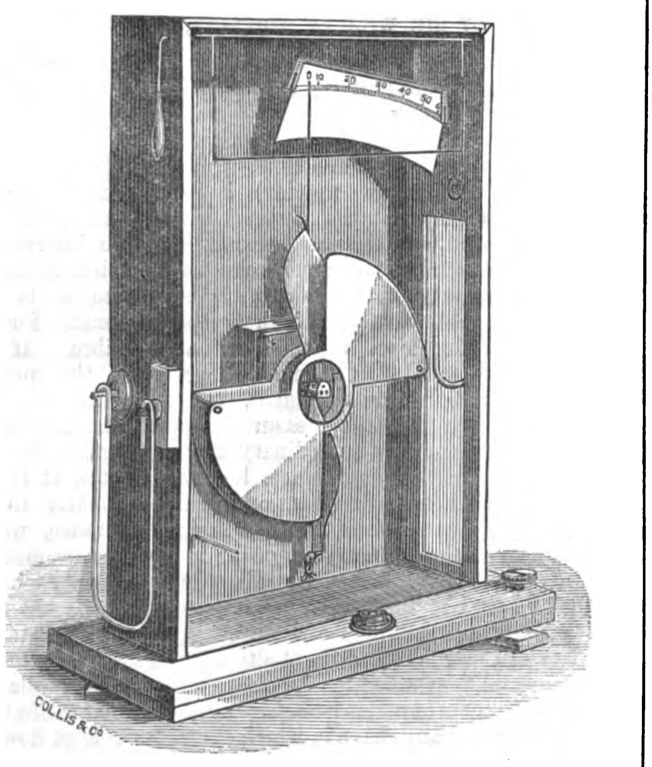
"Report on Electrometers and Electrostatic Measurements" in the British Association volume for 1887 (Report of the Committee on Electrical Standards), and reprinted as Article XX. of my "Collected Papers on Electrostatics and Magnetism," so I need say nothing more of it at present. The electrostatic voltmeter exhibited and shown in action this evening, and represented in the accompanying drawing, is an idiostatic standard instrument for measurement from 400 volts to 10,000 volts.

It consists of an air condenser, with one of its plates capable of a to-and-fro motion, so as to vary the capacity of the condenser.

The fixed brass plates are supported so as to be accurately parallel to each other, and in metallic connection, while they are thoroughly insulated from the case of the instrument. The movable plate is of aluminium, and is supported in a vertical position on a knife edge, the plane of its motion being parallel to the fixed plates, and situated midway between them. The upper end of this movable plate has a fine prolongation which serves as a pointer for indicating the deflections on the scale of the instrument, and at its lower end is fixed a knife edge having its length perpendicular to the plane in which the plate moves.



Sir William Thomson's Electrostatic Voltmeter.

There are two pairs of terminals, one pair for the fixed plates and the other pair for the movable plate, and each terminal is insulated from the case of the instrument. Of the pair on the left-hand side of the case, the terminal towards the back of the instrument is in metallic connection with the fixed brass plates, while that towards the front (which may be called the working terminal) is simply an insulated brass pin. A glass U-tube is suspended between these two terminals, and contains a safety-arc of finest copper wire connecting them. The terminal toward the back of the instrument on the right-hand side is in metallic connection, through the V-groove support, with the movable plate; in other respects the pair of terminals on the right is similar to the pair on the left.

In order to save time in taking readings an arrangement is provided for checking the oscillations of the movable plate, and stops are placed to limit its range and prevent damage to the pointer.

When the fixed and movable plates are connected respectively to two points of an electric circuit, between which there exists a difference of potential, the movable plate tends to move so as to augment the electrostatic capacity of the instrument, and the magnitude of the force concerned in any case is proportional to the square of the difference of potential by which it is produced. In the use of the instrument this force of attraction is balanced by the horizontal component of a weight of any convenient amount hung on the knife edge at the bottom of the movable plate.

The scale is graduated from 0 to 60, and the divisions represent equal differences of potential—the actual magnitude of the difference per division being dependent upon the weight in use at the time. A set of three weights is sent with each instrument, of respectively 32·5, 97·5, and 390 milligrammes, providing for three grades of measurement in the proportion of 1 : 2 : 4. Thus the instrument shows one division per 50 volts with the link (the lightest weight) alone on; one division per 100 volts with the medium weight hanging on the link, and one division per 200 volts with all three weights on.

At from 8,000 to 10,000 volts there is some liability of a spark passing between the movable plate and one or other of the four fixed quadrant plates between which it moves; 10,000 volts is about the highest potential for which the instrument can be used. For higher potentials my long-range electrometer ["Collected Papers on Electrostatics and Magnetism," sections 383-384] is, so far as I know, the only standard electrometer which has hitherto been practically used. But with the experience I have had of gravity instruments for electric balances in general, and particularly of the electrostatic voltmeter, I am now convinced that an electric balance for weighing the direct attractive force between a fixed plate and a movable disc will be the best form of standard electrometer for all potentials exceeding 8,000 or 10,000 volts. I hope before the close of next session to be able to show to the Philosophical Society a convenient instrument of this kind, adapted to measure from 10,000 to 40,000 volts, and possibly even to 70,000 or 80,000 volts; although I cannot anticipate for measurement of such high electric potentials any great practical demand as far as the future of electric technology can be conjectured at present.

The electrometer is available with equal convenience for the measurement of electric potentials in circuits of direct current, or of alternate current. In the latter application the result is quite definitely the square root of the time average value of the square of the difference of potentials between the points touched by its electrodes. A good deal is now being done for electric lighting and the electric transmission of power by means of circuits at high potentials of from 700 to 2,000 and 3,000 volts; and for such purposes the electrostatic voltmeter, described and illustrated above, is conveniently available. The method of finding potentials by measurement of current through a known resistance is also available even for these very high potentials; but the electrometer is preferable, because of the cumbrousness and expensiveness of the resistance coils required by the current-measuring method when the potential is more than 600 or 700 volts.

For potentials of from 500 volts downwards the method of measuring currents through resistance is thoroughly convenient and practical. Thus we are led to the consideration of the current measuring branch of our "two-branch" chain of measuring instruments.

Beginning with the feeblest current, I may refer to the astatic mirror galvanometer of the form introduced by me about twenty-eight years ago, and now much used for laboratory and telegraph testing. This instrument is capable of being adjusted to measure currents as low as the fifty millionth of a milliampere, with a coil of from 5,000 to 10,000 ohms. It has besides the great advantage that its sensibility can be easily varied through a wide range. Thus, an instrument which in its most sensitive state will measure the fifty millionth of a milliampere can be easily arranged to measure the thousandth of a millampere. Prof. S. P. Langley, of the Allegheny Observatory, United States, recently used in his radiation experiments one of these instruments which he had specially made, and which included several important improvements of his own, such as the use of a very long suspending fibre and a very perfect mirror. He finds it capable of being used with perfect accuracy for the measurement of the ten millionth of a milliampere. In ordinary telegraph testing these galvanometers

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are commonly adjusted to measure currents down to about the millionth of a milliampere, and for special tests, as, for instance, the measurement of the insulation of short lengths of core for submarine cable, sensibilities as high as those specified above are often used.

(*To be continued.*)

CABLES FOR ALTERNATING AND UNSTEADY CURRENTS.

At a recent meeting of the Electrotechnical Society of Berlin a paper was read by Herr Frischer, in which he describes some concentrically arranged double cables which have been made by Messrs. Siemens and Halske for underground electric lighting work.

If the cables are only required to carry low tension continuous currents no difficulty arises in the way of inductive effects on neighbouring telephone cables, but, as is well known, this is not so in the case of alternating currents or of high tension continuous currents (so-called). The external inductive effects can be almost entirely overcome, as is known, by twisting the direct and return cables together, and there is no difficulty in doing this in the case of cables of small sectional area, but with cables of large sectional area some practical difficulties arise.

If two such cables be separately enclosed in their leaden sheaths they cannot be properly twisted together, and if merely laid side by side the external inductive effects are not entirely done away with, and there is also an unnecessary waste of energy due to the currents induced in the sheaths. If on the other hand the two unsheathed cable be twisted together, surrounded by insulating material, and enclosed in a single sheath, there is a great waste of space.

This may be overcome to a certain extent by using four cables to make up the required stctional area of conducting wire and connecting them in pairs, so that two opposed cables, relatively to the centre of the cylindrical sheath are used for the direct current and the other two for the return current, but even in this arrangement there is a considerable waste of space and of insulating material.

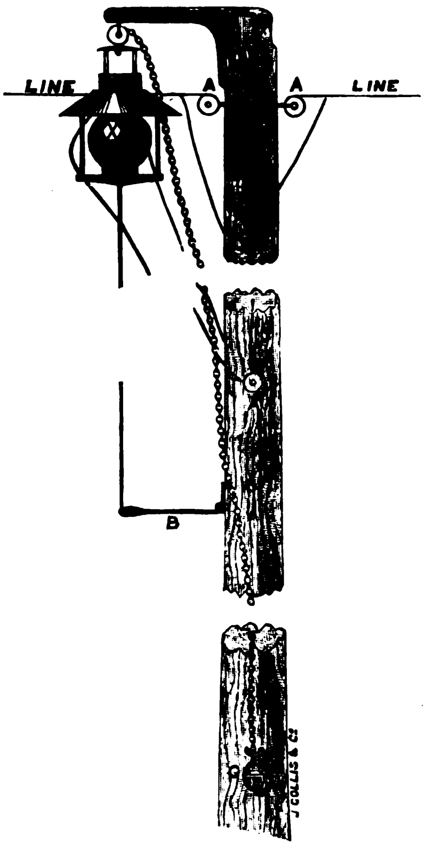
These considerations led to the design of a compound cable in which the wires of one of the constituent cables are massed together as usual in the centre, while the return cable is formed of wires arranged in a ring concentric with the other, the latter being surrounded and separated from the former by insulating material, while a single leaden sheath encloses the whole. This method of construction has the additional advantage that the cable may be enclosed by an outer protecting sheath of iron wire without loss of energy due to inductive action on the iron. The experimental determination of the insulation of cables made on this plan, carried out under water, is found to give an insulation resistance of ten thousand megohms per kilometre; and after making allowance for the inferior insulation of the joints of different sections, Messrs. Siemens and Halske are prepared to guarantee an insulation resistance in practice of a thousand millions of ohms per kilometre. The separate sections of the cable are joined together by means of cast-iron cylinders, which have their empty spaces filled up with insulating material after the ends of the cables have been firmly united. The ends are provided with specially constructed terminal pieces, in order to exclude moisture from the insulating material. About 25 kilometres of these cables had been laid down by the end of last year.

THE LIGHTING OF DUNDALK.

The little town of Dundalk, which is situated on the Irish coast, a few miles north of Dublin, will shortly have its streets lighted with twenty-four arcs of 3,000 candle-power. The installation has been planned and carried out by Mr. MacCarthy, electrical engineer and contractor, whose works are situated in the neighbourhood. We understand that Mr. MacCarthy has concluded a contract with the Town Commissioners for three years at the rate of £400 per annum, or £16. 13s. 4d. per arc. The lights are to run every night from dusk to daylight, except during the months of June and July, and also on five days in each month when the full moon is (or should be) visible. This clause—which is no doubt a very reasonable one—goes some way to explain the low price at which the contractor finds himself able to undertake the work. The Town Commissioners will save no less than £60 a year over their previous bill for public lighting, at the same time getting something like twelve times the amount of light.

The plant consists of a 30 horse-power (nominal) horizontal condensing engine and Cornish boiler, driving from a countershaft three "Excelsior" arc light dynamos at 1,000 revolutions. Buffalo hair belting, supplied by the Rossendale Belting Company, is used by Mr. MacCarthy, who speaks very highly of the merits of these belts. The machines are coupled in series, and each has an output of 620 volts and 16 to 17 amperes, giving 1,860 volts on the cables. The circuit consists of 6½ miles No. 8 B.W.G. bare copper wire run on poles through the streets; this entails a loss of 540 volts, or 12·3 horse-power. The lamps are of the Simplex pattern, taking 55 volts and 16 amperes, and are each fitted, as usual, with globe, storm-cover, and automatic cut-out.

The method of suspending the lamps and forming connection with the mains is in some respects novel, and seems well worthy of attention. Our illustration shows the plan adopted. It will be seen that a second pair of insulators is attached to the poles about half way from the top, and the leads, after being shackled off at the upper insulators, are connected to a length of 19/20^2 high insulation cable, which is brought down to the lower insulators before being carried loosely to the lamp. By this means the lamp can be raised and lowered without special gearing. The lamp is swung from the chain shown in the figure, and this is secured by a padlock passing through a staple at the bottom of the post. When the lamp is to be lowered an additional piece of chain is hooked on to the length attached to the post.



Street Lamp-post in Dundalk.

A A A, insulators; B, iron rod on hinge for holding lamp steady; C, padlock holding chain supporting lamp.

In order to steady the lamp a cord fastened at one end to the frame is also secured to a projecting iron bar half way down the pole, and this bar is hinged so as to fall flat against the pole when the lamp is lowered. These arrangements certainly have the merit of simplicity, and there seems to be no reason why they should not answer their purpose thoroughly well.

We have mentioned that the main leads consist of bare wire, but Mr. MacCarthy informs us that he has succeeded in obtaining high insulation by coating the wire for some distance on each side of the insulators, first with thin layers of gutta percha tissue, and next with two layers of vulcanised tape, separated by a layer of tar, and finally with tar again on the outside.

The whole of the 24 lamps are not yet placed in position, although everything else is complete, and one or two trial runs have been made with a portion of the lamps, and with satisfactory results. The remaining lamps will be hung as soon as received from the makers, and the installation will at once be started. We have no doubt that the operation of the plant will be thoroughly successful in Mr. M'Carthy's hands, and we shall be glad to learn at the end of twelve months that he finds the arrangement satisfactory from a financial point of view.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 535
Incandescent Lamp Manufacture.—XIV. By J. Swinburne. Illustrated ... 539
On Regulating Series-Wound Transformers. Illustrated... 540
Electrical Measuring Instruments. By Sir W. Thomson, F.R.S. Illustrated ... 541
Cables for Alternating and Unsteady Currents ... 543
The Lighting of Dundalk. Illustrated. ... 543
THE EMPIRE AND ITS CABLES.. 544
Correspondence. Illustrated.. 545
The "Volta" Disaster ... 548
The Short-Nesmith Electric Railway System. Illustrated 549
Distribution of Electricity by Means of Secondary Generators ... 551
Physical Society ... 551
Companies' Meetings—
Indo-European Telegraph Company ... 551
Eastern Extension, Australasia, and China Telegraph Company ... 552
Reuter's Telegram Company. 554
Oriental Telegraph Co. ... 554
Equitable Telephone Association ... 555
West Coast of America Telegraph Company ... 555
City Notes, &c. ... 555
Companies' Share List ... 555

THE EMPIRE AND ITS CABLES.

Mr. HENNIKER HEATON, M.P., not content with the opportunities of the Colonial Conference for displaying that peculiar form of patriotism which runs down the mother country in order to back up the interests of her colonies, has been supplying the newspapers with what he is pleased to call "information" about the imperial postage and telegraph systems. Last Sunday a long letter of his, dealing with these subjects, appeared in the *Observer*, and not many weeks ago that eminently conservative journal, the *Pall Mall Gazette*, was favoured with a similar communication from the same hand. We begin to suspect that the conservative member for Canterbury cannot find an outlet for his views in the recognised organs of his party. This, indeed, would not be very surprising, seeing that party politics in the colony where Mr. HEATON learnt his trade are in a somewhat topsy-turvey condition, every liberal being a protectionist and every conservative a free trader. We are even told that it is quite the correct thing for a professed Conservative to be correspondent of a colonial Home Rule journal; and we know that Mr. HENNIKER HEATON, fresh from colonial Conservatism, has propounded doctrines commonly associated with a "Federation" which is neither colonial nor conservative, but "Social and Democratic." Charity would suggest that Mr. HEATON missed his way in English politics, and that he landed with a primrose in his buttonhole not knowing what it meant. But as he continues to sit on the Tory benches, we are constrained to account for this conflict between political profession and public action in a man who evidently knows what he is about by assuming that he is here as the emissary of some colonial interest, the advocacy of which is not to be trammelled by the political or social scruples of English public life. At the Berlin Telegraph Conference Mr. HENNIKER HEATON, as a Colonial agent, proved himself to be a rather troublesome customer; in the British House of Commons he is a rather dangerous one.

His latest contribution to the English press devotes a column and a half to an Imperial Ocean Penny Postage; and only a paragraph to the Acquisition of Ocean Telegraphs by the "British and Australian Governments." Why by Australia, of all the colonies, is not apparent, except that Mr. HEATON seems to hold a brief for Australia, his instructions being to make a dead set against those English companies whose cables serve the Australian colonies. Mr. HEATON is divided in his opinion as to whether an Ocean Mail service should be created by these Governments, or the cables be purchased out of the funds paid for mail contracts by the British Post Office. This money he calculates, or rather he asserts, would suffice for one or the other; and as he is equally enthusiastic about each, we gather that somehow he would make the money do for both. We quite believe that he would; for when he talks about the "millions of misspent capital" laid out on cables in the past, it is plain that the purchase he recommends would take no account of what the companies have spent. But as Mr. HEATON'S confiscatory doctrines are not largely entertained in the British Parliament, we need say no more about them. When, however, he goes on to declare that "the cable monopoly, like the mail contract monopoly, must be broken down," we hasten to assure him that the cable monopolists will offer no objection. Buy them up at a fair price, and then the "British and Australian Governments" can do exactly what they please with their own. Whatever tariffs are then charged over those lines, whether a shilling or a penny, will be a matter of indifference to the proprietors as such, though they might still have a voice in the matter as taxpayers. Reference to the dividends paid on these submarine cables ought to satisfy Mr. HEATON that the rate of one shilling a word, which he considers "reasonable," would be far from reasonable if he were the sole proprietor. Nor would he care to try the experiment if the loss had to be borne by himself until the growth of business made that tariff remunerative.

But the fact is Mr. HENNIKER HEATON'S clients pay no heed to considerations of equity where other people's property or capital is concerned. They want to reduce the price of postage and telegraph, and as they cannot induce the British Post Office or the British cable companies to sacrifice themselves on the altar of colonial interests, they covertly preach confiscation and breach of contract as articles of Imperial faith. Mr. HEATON'S standpoint, as well as his qualities as an advocate, may be judged by what he says about mail contracts. He argues for uniform penny postage between Great Britain and her Colonies, although he admits that the Colonies have not adopted it for themselves, whereas we have. Uniformity is undoubtedly desirable, and we agree with him that preference rates should prevail throughout the British dominions. But we never should have had penny postage for ourselves,

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and colonial inland postage would be dearer now than it actually is, if uniformity had been aimed at instead of cheapness. The loss on one system would have had to be made good by the profit on another, and a heavier rate would have been maintained all round. Mr. HEATON, in condemning the excessive profits on certain mail contracts, overlooks the heavy losses on others; and, similarly, in his arguments for the abolition of cable monopolies, he forgets that even were they to be sequestrated as felonious property the losses entailed by experimental tariffs of a uniform and popular kind must be made good somehow. Logically we ought to raise our inland telegraph tariff from a halfpenny per word to one shilling per word in order to reduce inter-colonial and imperial tariffs to that figure. In one instance cited by Mr. HEATON the mail service costs £353,000 a year, although the revenue amounts only to £55,000. He protests against this charge, just as he protests in advance against taking any account of what he calls the misspent capital of the cable companies—meaning the money expended in making submarine telegraphy a practical system. He again forgets that honest work has to be honestly paid for—at all events in the mother country—and that where the work is exceptionally expensive it must be covered by additional rates, by Government subsidy, or by compensating profits in other directions. And this would be true of any scheme which resulted in the transfer of cable property to the Imperial Governments.

Of the extravagant lengths to which Mr. HEATON is carried by his instructions we need only mention one or two examples. An "iniquitous" charge of 1½d. is made by France and Italy on every letter we send *vià* Brindisi; therefore, that route is to be given up, though it is the quickest. The route *vià* the Cape is the one which lends itself best to a penny postage scheme, therefore the Cape route is to be observed, though it is the longest. Similarly, Mr. HEATON is a warm supporter of new and roundabout cables through unexplored and dangerous seas in order to save the "iniquitous" charges of foreign lands over which the direct routes lie. Perhaps the most heroic of his propositions is the building of swift steamships to carry the mails ourselves, instead of letting them out by contract. Capitalise the subsidy, says Mr. HEATON, and you could build these ships. Be it so; but could we man them, work them, and rebuild them when worn out? Ships, like cables, have to be replaced when disabled; and, seeing that private mail contractors cannot afford to run ships without a heavy subsidy, it follows that no Government could run their own ships except at a loss equal to the subsidy—unless, indeed, they became competitive shippers of cargo and passengers as well as Government mail carriers. We have said that Mr. HENNIKER HEATON is a dangerous person, but chiefly because he comes to swell the ranks of that active propaganda whose extremest exponents are to he seen on Hyde Park platforms on Sunday afternoons. In his case, perhaps, the danger is greater because he knows nothing of the history of submarine cable enterprise, and is out of sympathy with its promoters. We have one hope for him, however, namely, that he may in time discover that in England the prejudice against monopolies, so far as it exists, is as strong against the monopoly of a Government as against that of a private company. At present the British Post Office does not run its own trains, nor sail its own ships, nor even horse its own mail carts; and we do not anticipate that the country will yet awhile enter upon the gigantic operation of buying up and working Submarine Telegraphs, even at Mr. HENNIKER HEATON'S valuation. Meantime, we repeat, if the Australian or the British Governments want them, they can have these cables any day by paying an honest price for them.

CORRESPONDENCE.

THEORY OF SECONDARY CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Swinburne says that I am "certainly working with a mixture of the old and new notations." May I ask him to specify any case in which, when referring to calorific equivalents, I have quoted a value other than that related to the chemical *equivalent* weight expressed in grams? I think he is called upon to comply with this request because, although he ascribes to me an egregious blunder in the most pleasant and playful style (assuring me, moreover, that he does not want to insult me), it is well known amongst my old pupils and others, not only that I lay claim to that degree of accuracy which is ensured by strict care and due consideration in writing upon a scientific subject, but that, in sundry examinations, I have been "rather rough upon" others guilty of such blunders. It would be "fine fun" for some of these young gentlemen to see me caught tripping!

I do not quite understand on what point I am, in Mr. Swinburne's estimation, "seventeen years behind the age." Is it because I attach importance to the splendid work done by Dulong, Andrews, and Favre and Silbermann—of which Mr. Swinburne would seem to say "*nous avons changé tout celà?*" Is it because he thinks that I have not "taken cognizance" of the introduction of the automic system of notation now universally used in chemistry? Or is it because I hold that differences of valency mean differences in the electrical capacity of the atom, that the chemical equivalent weights are also electro-chemical equivalents, whereas the chemical atomic weights are associated with different quantities of electricity according to their difference of valency; and that, therefore, I use in electricity the simple equivalent weights, instead of complicating matters by manufacturing equivalent weights from the atomic weights?

Does Mr. Swinburne really mean to say and to repeat that in effecting the combination of 206·4 grams of Pb with O and with SO_3 (simultaneously or consecutively) he would expect to obtain 156,110 calories? If so, is he aware that the gram atomic weight of Zn (64·9 grams) when combining with SO_4 evolves no more than 106,838 calories, and this being the case, would he be prepared to admit that Pb is strongly electropositive to Zn, or would he prefer the alternative of denying the doctrine of the conservation of energy?

Another question is suggested by Mr. Swinburne's letter. If I form a couple of amalgamated zinc and *brass* in dilute sulphuric acid, would it be correct to say in regard to the method of calculating the E.M.F., "Sulphate of zinc being formed at both plates is, of course, put twice on the credit side?"—Yours, &c., DESMOND G. FITZGERALD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Resuming this subject exactly where Mr. Swinburne leaves it, I will explain to your correspondent that I styled him a "chemist" on account of the character of his scientific contributions, and that the title was in my mind one of appreciation. I am glad to gather from his explanations that there is no case against him for invented agencies.

On the particular point of the sulphate of lead formed on both, plates I must ask to say a word more. As regards the sulphate formed on the spongy plate, I quite agree to this combination being credited, but the Pb, SO_4 at the other plate certainly cannot be credited, because, as I will explain, it is an action *back to back* with the one first mentioned. It could be credited only if the metallic component of the sulphate had been furnished by the liquid and the acid component by the plate, the existing case being just the reverse. Nor would I hastily assert that the combination Pb, SO_4 at this peroxide plate should be debited either, though it may in some way modify the E.M.F. of the cell. But it is certain that the two formations of lead-sulphate cannot possibly be upon the same electrolytic thread, for the polar sequence I have alluded to in the components from whose affinity the E.M.F. arises is an

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essential principle in the matter. Speaking intuitively, I should say that the formation of Pb SO_4 at the peroxide plate is probably a local affair, and non-adjuvant, or, rather, *non-opponent*, for the combining couple is set the wrong way to have a chance of being *adjuvant*.

As to the reckonings with the Daniell cell, my results would be just the same as Mr. Swinburne's; and turning again to the secondary cell, if I have put my pen through a large item on the credit side, and thus thrown the balance ten times as much wrong the other way, I have merely done my duty as an auditor, and it will be encouraging to reflect that the discrepancy in a balance-sheet often gets worse as the first step towards vanishing altogether. But let Mr. Swinburne go on, and I have no doubt he will get his accounts right, and will end by explaining it all both to himself and to us. The investigation upon which he, as well as others, has entered is, I fear, too formidable a one for myself to go right through independently. I have therefore to ask his indulgence if I leave the work of auditing in a half-finished state, at least for the present.—Yours, &c., E. ALDRED WILLIAMS.

37, Burlington-road, W.

NOTES ON THE PERFORMANCE OF SOME DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I enclose a table correcting a few errors in the very interesting table by Mr. D. C. Jackson, in *The Electrician*, April 15, page 499. It will be seen that for the Goolden-Trotter dynamo, 56 v. 285 a., the figures in Columns I., II., and III. should be about doubled. The error has evidently occurred from the fact that the armature is wound with two wires in parallel, and the compiler has taken the effective length to be 440ft. instead of 220ft. The figures in Column II. Goolden-Trotter 60 v. 200 a. should be ·0061, and I have filled in the remaining columns.

Machine.	Revs. per. min	Velocities.	I.	II.	III.	E.M.F	Current.
Edison-Hopkinson...	800	2,100	·483	·0138	·00060	110	300
Goolden-Trotter......	800	3,000	·378	·0075	·00047	130	200
,, ,, ...	765	2,140	·264	·0074	·00034	56	285
,, ,, ...	950	2,850	·289	·0061	·00030	60	200

Column II. of the Edison-Hopkinson should be ·483, and Column III. ·0006, *not ·006*. I have checked these from Mr. Kapp's figures in the paper mentioned below. I also give the data of a larger Goolden-Trotter dynamo.

In the discussion on the paper by Mr. Kapp read before the Institute of Civil Engineers, November, 1885, I pointed out that it was hardly fair to compare the length of wire per volt unless the machines were of the same output, as the length of a turn is only proportional to the square root of the armature core sectional area, and consequently a large machine has a decided advantage over a small one.

The errors pointed out are rather serious, as they make out the Goolden-Trotter dynamos to be little better than the "Old Gramme," which would be very damaging to the reputation of both makers and designer.—Yours, &c.,

H. RAVENSHAW.

42, Salisbury-place, Halifax, Yorks.

VOLTS AND CALORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I would advise Mr. Swinburne to read the little book "Old or New Chemistry; which is Fittest for Survival?"*

As we are all in the pursuit of truth, with more or less of purity of aim, I think it ill becomes Mr. Swinburne to make flippant remarks against Mr. FitzGerald, and rating him as seventeen years behind the age, &c., &c., the more so as I believe Mr. FitzGerald has from first to last uniformly followed the calorific values of the old, or *equivalent* notation; whereas all the confusion has been due to Mr. Swinburne and others who are misled by the absurdities of our modern notation. It is as curious as it is instructive to note that Mr. Swinburne's friends, whenever they are impelled or necessitated to estimate the *real relations*, do so by a kind of "hocus pocus," which certainly reduces matters to an equivalence with the old notation. One of the latest cases observed is that of Lord Rayleigh, who in a very profound estimate of the electrolytic relations of copper and silver, by a very roundabout process of learned experimentation, including the "hocus pocus," deduces the ratio for these elements of 3·4, where initially the atomic weights are supposed to be as 63 to 108 within small fractions. Of course this gives no such ratio.

I then compare notes by taking my old equivalent values, with no pretension of wonderful exactitude, and find Cu = 31·7 and Ag = 108; and $\frac{108}{31{\cdot}7} = 3{\cdot}4$!

Another case is that of Mr. Robert Sabine, who in a very able study of the "electricity disengaged between mercury surfaces" had occasion to compare the volumes of metal and its protoxide, and hence to deduce the square root of their ratio; and taking his estimate of the specific gravities, the problem is indeed a very simple one. Thus Hg = 200 ÷ 13·595 = 14·7; and Hg O = 208 ÷ 10·69 = 19·45; while the square root of this ratio = $\sqrt{\frac{19{\cdot}45}{14{\cdot}7}} = 1{\cdot}098$. We need not go into the reasoning involved in his argument from these data, but simply note his method of obtaining this result. He says:—"The atomic weight of Hg is 200, and its specific gravity = 13·592; hence its volume is 14·7. The atomic weight of the protoxide is Hg_2O = 416, and its specific gravity = 10·69; hence its volume is $\frac{416}{10{\cdot}69} = 38{\cdot}9$," a figure which may delight Mr. Swinburne and many others. But now for the "hocus pocus." He then gets $\sqrt{\frac{38{\cdot}9}{2 \times 14{\cdot}7}} = 1{\cdot}098$!

Now let these two cases be taken as universally typical, and when Prof. Silvanus Thompson estimates the volt to be worth 46,000 calories, or Mr. Armstrong, in a recent study of electrolysis, before the Royal Society, estimates 40,000 calories to the volt, I would say to both these gentlemen, "Go back, and read your lesson anew; and if you can divest yourselves of bewildering hypothesis, you *must* admit that the calorific energy involved in one volt of electric potential is about *one half* of the alleged values."

One word as to Prof. Tyndall's eloquent and beautiful treatment of the energy involved in the formation of water, in his "Heat, a Mode of Motion." Of course, the value of H_2O = 18 would be 68,000 calories; but he is too sound a thinker to be deluded by diatomic hypothesis, hence his wonderful results are all based on the absolute fact that HO = 9 = 34,000 calories, &c.—Yours, &c.

SAMUEL E. PHILLIPS, F.C.S.

* Lea, Wertheimer and Co., London-wall.

NOVEL PHENOMENA OF ALTERNATING CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN

SIR: IN your report of the proceedings of the Physical Society for March 12th—which report appears in your issue of March 25th—reference is had to an experiment, said to be due to Dr. Fleming, in which a disc of copper movable in the axis of a coil of wire is deflected by passing undulatory currents round the coil.

Mr. Shelford Bidwell is reported to have said that he had not arrived at any satisfactory explanation of the deflection of the copper disc. The phenomenon in question has been quite familiar to me for a considerable time past, and was discovered in experimenting with induction coils, using alternating currents, for the welding of metals.

The action of the copper disc in the experiment referred to is really but one instance of a large variety of similar actions which I have obtained with alternating currents in coils when in inductive relation with closed circuits as closed rings, bands, coils, discs, plates, cylinders, &c. Moreover, to obtain an

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explanation of the phenomena presented no difficulty, as the theory of the action is quite simple.

I shall, within a short time, publish the results of my experiments. They have, in fact, been made the basis of the construction of alternating-current indicators, &c., and of alternating-current motors which start from a state of rest.

In general, I have found that a mutual repulsion, or rather an excess of repulsion over attraction, is exerted between a coil conveying alternating currents and a closed path for current, such as a conducting band or coil, when the path for current in the latter is parallel, or at any angle less than a right angle with the former.

The same repulsion is exerted between an alternating magnetic pole or poles and a closed coil or circuit when any of the lines from said pole pass through the axis of the coil or circuit at any angle.

The action of repulsion is variable in amount with the relative position of the inducing coil and the closed secondary coil or circuit, and is quite energetic when the resistance of the secondary or closed circuit is very low, as when made of heavy copper, or, what is practically the same, of an equal amount of copper wire of any size connected with a closed circuit. In such case, currents representing many ampere turns are induced in it, and the self-induction developed by them is so great as to cause the phases of their alternating impulses to undergo a considerable shifting or lag beyond the positions they would have if determined solely by the inductive actions of the impulses in the primary coil, or alternating current coil, to the changes in which current the secondary currents are primarily due.

The explanation of the resultant mutual repulsive action exhibited, or of the deflective action, when the parts are so mounted as to be only capable of showing the repulsion by a deflection, is simple. By self and mutual induction there is caused a lagging of the induced waves of current in the closed coil, band, disc, &c., beyond the positions which, if represented graphically, they would have occupied if entirely free from the effects of self-induction, and were governed by the inducing action of the primary currents of the alternating-current coil. The lagging of the phase of the induced current, however, makes the currents in the two conductors, primary and secondary, tend to be *opposite* in direction at the times when the currents are *strongest*, and to be in the *same* direction at the times when the currents are *weakest*, as when near the zero of current.

The result is that the repulsion produced by the *opposite strong* currents, minus the attraction produced by the *weak* currents of the *same* direction, is a more or less vigorous repulsion.

I must leave further elaboration and discussion of this subject until the publication of a paper which I now have in preparation, and in which diagrams of the arrangements experimented with will be given, together with g raphic representations of the combined effects of mutual and self induction in causing such an altered relation of inducing and induced currents as to give rise to a preponderance in the repulsive actions over attractive actions.—Yours, &c.,

Lynn, Mass., April 12, 1887. ELIHU THOMSON.

COMPOUND WINDING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following extract from a patent of Mr. S. A. Varley, No. 4905, of the year 1876, may be of interest to dynamo manufacturers of the present time:—

"Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light. There are several well known ways of doing this, but the method I prefer is to wrap the soft iron magnets with *two* insulated wires, one having a *larger resistance* than the other. The circuit of larger resistance is always closed, and the circuit of less resistance is used for the electric light.

"When the electric light is being produced, the *greater portion* of electricity passes though the circuit of less resistance, which I term the 'electric light circuit,' maintaining the magnetism of the magnets, and producing the light. When the electric light circuit is opened from any cause, the electricity developed passes through the circuit of greater resistance *only*, and maintains the magnetism of the magnets."

This method of winding is not claimed.—Yours, &c.,

EDGAR SMART.

11, Wells-street, Gray's Inn-road, W.C.,
April 23rd, 1887.

INCANDESCENT LAMPS FOR SERIES CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We notice in your issue of March 18, under the head of "Incandescent Lamps for Series Circuits," a description of our new series socket. As some statements are made which may be misleading, we should like to make the following comments:—

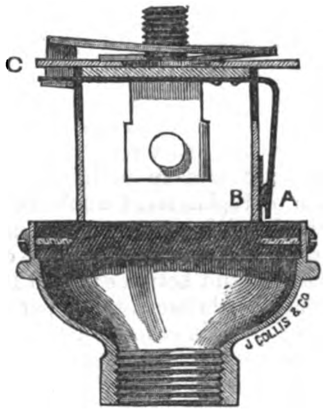

FIG. 1.

The cut-out in our series socket, consisting of the spring A, separated from the socket frame B by a thin piece of oiled paper, is called by us a film cut-out. It is not intended as the main cut-out of the lamp, but is merely an *auxiliary safety device*, not called into action once in a hundred times. The true cut-out for the lamp is contained in the lamp itself. It is constructed by twisting by each other in the glass stem the platinum wires leading from the filament.

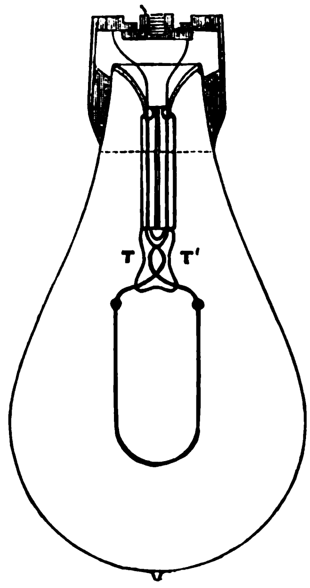

FIG. 2.

Upon the destruction of the filament an arc is formed between the platinum terminals, which arc, upon reaching the twisted portion, melts the wires together, thus preserving the continuity of the circuit. This cut-out is shown in the accom-

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panying Fig. 2, where T T' are the platinum leading wires, sealed into the glass, and twisted together. This cut-out has operated hundreds of times without a single failure.

If the arc produced by the destruction of the filament should break the glass, which has been known to occur occasionally, the consequent inrush of air is liable to blow out the arc, and thus open the circuit. It is then that the film cut-out comes into operation, as stated in your description.

In regard to your fear that "it would be hazardous to meddle with the spring A," we would say that it is unnecessary to meddle with this spring, except in the case of the non-operation of the cut-out mentioned, which very rarely occurs. Even then it is not hazardous, as the socket is provided with a spring cut out, indicated at C in Fig. 1, which spring cut-out shunts the film at A when the lamp is removed from the socket. It is also our custom to place in connection with the socket a ceiling-board, provided with a shunting switch, and our directions are to always close this shunting switch before doing anything to the lamp.

In the case assumed by you—*i.e.*, that of a new lamp being put into place while the circuit is in operation, and an attempt made to replace the insulating film under the spring A, and the lamp assumed not to be making good contact, a combination of circumstances which you term "hazardous," there still would be no danger or hazard in undertaking to replace the film. The operation of replacement would be done ordinarily by prizing up the spring A by means of a knife blade, screw-driver, or some other tool, which would, of course, for a moment act as a short-circuit between A and B and permit the easy placing of a new film between these parts. Now, on the withdrawal of the knife blade or tool used to hold the contacts A and B apart, there would be, of course, in the case of no connection existing through the lamp, an arc formed between A and B, which would immediately char or destroy the film and again short-circuit the arrangement, at once calling attention to the fact that there was no good connection through the lamp itself. This experiment has been repeatedly tried at our factory, we having purposely produced the assumed hazardous conditions to which you refer.—Yours, &c.,

E. W. Rice, Jun., Superintendent.

Lynn, Mass., April 2, 1887.

DOUBLE OVERHEAD WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: If any of the readers of your valuable journal could give me some hints as to the employment of double overhead wires as used to prevent "cross talk" in telephone circuits I should feel much obliged.

The circuits in question consist of four telephone lines to an outlying village about three miles distant from our centre, and perfectly free from telegraph induction.

As the four lines would necessitate eight wires, would it be sufficient for each pair to revolve round themselves, as practised with a single line, or must the whole system revolve?

If the latter be necessary, the running of these wires would become rather complicated, and I should be very thankful of the assistance of any one who has had experience in this direction.—Yours, &c., Puzzled.

April 27th, 1887.

ELECTRIC LIGHTING PLANT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Permit me to point out a partial error in a paragraph quoted from an American journal in your issue of April 1st, stating that "until quite recently the whole of the electric lighting plant in use in the United States Navy had been imported from France."

This is true concerning the search light plant, but the incandescent light plant has been American in all cases.—Yours, &c.,

Bradley A. Fiske, Lieutenant U.S.N.

New York, April 14, 1887.

THE "VOLTA" DISASTER.

The following extract from a letter of Mr. E. H. Draper, one of the survivors of the "Volta," dated Myconi, 19th April, 1887, is a very graphic description of the disaster, and will appeal forcibly to many who have constantly to contend against the inconstancy of the waves:—

My dear Father: I am safe and well in body and mind. They thought at first I was drowned, and did not know till evening that I was safely here.

When the ship went ashore I was sleeping in the testing-room, which is in the forward part of the ship. I was sleeping there because Captain Richardson had the chief electrician's cabin, and Mr. Boyes was using mine. I was awakened by the thumping of the ship on the rocks, and did not know what was the matter for a little while; but some one told me that the ship was ashore, so I put on my trousers, vest, and coat, and went up on deck. When I got there I found the ship was hard and fast on the rocks, and I thought we should all be safely landed. I then went to help get out the boats, but before any of them could be launched the stern of the ship sank, and the water rushed forward like a sluice. I then went and got on the gunwale, but a great sea came along and washed me overboard. I struck out for shore, but there was a tremendous sea running, and my clothes were keeping me down. I managed, however, to take off my coat in the water, and that very nearly exhausted me. Every wave came over my head, and I got full of water, and then I thought I was lost. I had sunk down, and was apparently insensible, when, by a miracle, I felt the ribs of a capsized boat. I clung to that with all my strength, got on the top of it, and got hold of the keel. Then I was so weak that the waves washed me off, and I had to keep swimming and grasping at it again. At last I saw a light in another boat, and shouted, but they could not get near me, having no oars, so I made a last effort and swam for it, but could not reach it.

Very fortunately a wave took me, and washed me up to it, and the second officer, who had just been picked up by a boy in the boat, caught hold of my hair and hauled me in to it; they put me into the bottom of the boat, to regain strength, and picked up some oars that were floating by. Then they looked out for more people to save, but could see none in the water alive.

When I recovered my senses I found three more besides myself in the boat—all exhausted, so I got up and took the oars and tried to row. She was full of water, but having watertight compartments we were able to stop outside the surf till it was light, the hail and rain coming down in a dreadful way.

At daylight we struck out for a sandy beach we saw; when we got there we had just sufficient strength to run the boat on to the sand and get out. We laid down there in our wet things several hours, shivering and moaning with pain and weakness; but about eleven o'clock some Greeks came down and made a fire for us, so we lay down again beside it and dried our clothes, and then got away to the bay where the ship was.

We saw the people in the rigging, but were not able to give them any help whatever, so we set out for the town about five miles off. When we had gone about a mile we saw some donkeys on the road, and got on them, and rode away to a cottage, where the people very kindly made us some soup and gave us food. Afterwards we went to the town, and on arriving there I went to the telegraph office to say that we were safe.

A gentleman asked me to go to his house and have some supper and go to bed; their people were very kind. Some of the bodies had been brought to the house where I slept. When I got in the people were as pleased as if I had belonged to them, crying and laughing all at once.

One of the sailors, a Greek—a splendid fellow, who got ashore by digging his knife in the rocks, and so holding on till help arrived—said he would take care of me, and told the people on his arrival that he had seen me sink, and reported it in the town. I suppose this was when I went down, and he could not have seen me come up again.

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THE SHORT-NESMITH ELECTRIC RAILWAY SYSTEM.

In the month of February, 1885, a company was organised in Denver, Col., under the name of the Denver Electric and Cable Railway Company, for the purpose of building and operating an electric railway in the streets of Denver. It adopted a plan proposed by Mr. Sydney H. Short, then Professor of Physics in the University of Denver, who called the attention of the gentlemen comprising the company to his system of series electrical railway; and as an experiment a short piece of track, between three and four hundred feet in length, was laid in a circle in the University grounds.

A small car named "Joseph Henry" was built for the track and carried many hundreds of people. The success of this little road encouraged the company to make more extended experiments in this direction.

The first road was built on the following plan:—Two bare conductors were laid side by side along the track in a small conduit placed between the rails. The conductors were small and supported on insulators attached to the cross ties, and they were cut into sections in order to test the working of the system. Switches operated by the current connected the two conductors in multiple arc, making them practically one conductor, having the conductivity and sectional area of the two. These electrical switches at the same time connected the ends of the sections of this double conductor, making one continuous conductor along the entire length of the track. The ends of this working conductor were connected by means of wire with the dynamo. When a car was placed on the track and had its brushes or contact springs one on each of the parallel conductors of any section, the electrical switches at each end of that section would at once disconnect one of these conductors at one end and the other at the other end, leaving the only path for the current along one conductor, through the motor to the other conductor and to the line again. These sections could be made any convenient length, from that of an ordinary car to a block or a mile. A car could be on every section, and the same current would pass through all of them.

Mr. Short maintained that greater economy in electrical railways was to be had by the use of a constant current of small quantity, by running the cars in series like arc lamps or telegraph instruments, and varying the electromotive force with the power required to operate the line of road. This main principle has not been varied from since the beginning, but many modifications of the details of construction have been made from time to time. The two conductors used in the first arrangement were intended to carry the current in the same direction at the same time along the track, and, as stated above, they became electrically one conductor. At the junction of the two sections there were four contacts to be operated by an electrical circuit closer, which was necessarily a complex and delicate piece of mechanism to keep in good working order, especially when placed on the street where it was liable to injury.

Mr. Short therefore set about to devise some means of combining the two wires in order to do away with one pair of contacts at the junction of the sections, and thus to lessen by one-half the chance for leakage from the insulating supports. He found only one thing to do, *i.e.*, to shorten the sections of the conductor to the length of one car or train of cars. This increased the number of circuit closers greatly, but at the same it increased the flexibility of the road, as cars could be run as close together as they could be placed upon the track.

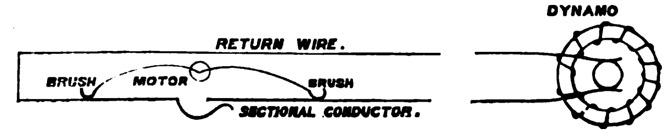

Fig. 1.

On this plan a contact brush must be placed under each end of the car or train of cars to make electrical connection with the conductor, so that there will always be a circuit closer between these brushes, as shown in Fig. 1. The circuit-closer between these two brushes must, however, be kept open as long as it remains between these brushes, and must close the line as soon as it passes from between them.

Electrical means for accomplishing this were devised, but were open to the same objection as the one referred to above, and with the large increase in number this objection became still greater. It thus became evident that a mechanical circuit-breaker must be used. Mr. Short presented this plan to Mr. John W. Nesmith, a practical mechanic of long experience, and asked him to devise some mechanical means for keeping the spring or circuit-closer, shown in Fig 1, open as long as the car was over it. Mr. Nesmith proposed that a long, slender bar of insulating material be stretched between the two current-collectors or brushes, this bar to slide between the contacts at the ends of the sections of the conductor and keep them apart so long as the car is passing, as shown in Fig. 2.

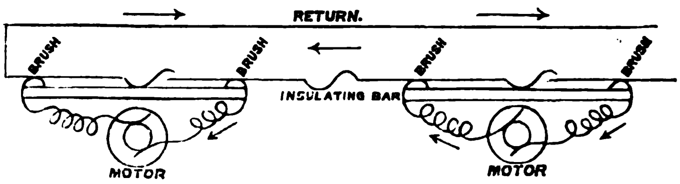

Fig. 2.

In July, 1885, this second plan was tried on about three hundred feet of track with the same car used in the first experiment. A brush at each end of the car made contact with two sections of the conductor, and a leather strap stretched between the two brushes kept the springs apart as the car passed over the circuit-closer. This experiment was a highly successful one, and the desired end was attained.

The Denver Electric and Cable Railway Company in consequence ordered the material to lay one-half mile of track upon this plan, and also two motors and one dynamo of the Short type. A small engine made by the Colorado Ironworks, of which Mr. Nesmith is proprietor, was put in place near one end of the line. This engine was of the ordinary slide-valve form, with a cylinder 9in. by 12in. Two beautiful coaches were built by Woeber Brothers, in Denver.

The electric conductor used in this trial was a slotted copper tube of about one inch inside diameter. Each tube was about 16ft. long and embedded in asphaltum and tar. The whole was encased in an iron shell and a slot was cut through at the top. These centre rails were spiked to the ties. Between the ends of these sectional conductors were mechanical contact closers. The car was provided with a contact brush at each end, which fitted into the tubular conductor like a gun-wiper brush. Between these brushes was stretched a long, flexible rubber cylinder which almost filled the tube. As the car moved along the forward brush was pushed through the tube and contacts at the ends; the rubber rod followed and kept the contacts apart until the rear brush had passed and the current was forced to pass from one brush through the motor and back to the other brush.

In October, 1885, this half mile of track was completed, and for the first time a car driven by electricity made its appearance in Fifteenth-street, in Denver. The experience of a few days showed this plan to be impracticable on account of the difficulty of keeping the conductor insulated. A very little sand and dust in the tube would stop the brushes. The most serious difficulty to overcome, however, was the leakage due to imperfect insulation.

To overcome this difficulty an ordinary underground cable was substituted for the bare conductor. This, by Mr. Nesmith's suggestion, was laid in the ground outside of the conduit, leaving the conduit for the passage of the current-collecting brushes, and mechanical circuit-closing springs were placed at intervals in the conduit, as before. By this arrangement it was necessary to provide careful insulation only for the exposed ends of the sections of the

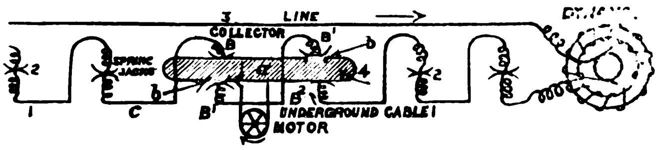

Fig. 3.

conductor. This was a great stride towards success with the conduit system, but the change in the arrangement of conductors made a new device for connecting the current collectors necessary. This was accomplished by the construction of a collecting bar shown diagrammatically at *a* in Fig. 3. As will be seen, three adjoining sections of the underground cable are connected with the two circuit closers B B. But when the current collector is removed from the circuit closers B B, these closers are in contact, and the line is continuous.

The current collector is made of a slender bar of insulating material, somewhat longer than the section of the conductor between circuit closers. Metal strips are fastened around the entire edge of the bar, except at *b*, *b*, where there are short insulated breaks,

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as shown. Wires pass from these metal strips to the motor. The current passes from the line to one metal strip, *viâ* the contact B, through the motor to the second metal strip, and thence to the line *viâ* contact B_2. The middle section B′ B′ of the conductor is cut out of circuit when the current collector is in the position shown in the figure. If the bar be moved in either direction it will be seen that no flashing can occur, nor can the line be short-circuited. This current collector is 2½in. by 1½in. in section, and about the length of a car. It is supported in the conduit by attachments passing down through the slot. In November, 1885, the company put down on the same street 500ft. of the new line of insulated wire for one of these current-collectors, and it worked to perfect satisfaction. During the winter of 1885 and 1886 this short line was worked in all kinds of weather, in snow, rain, and mud. The tracks were flooded and the severest possible tests were made to prove its merits and it never failed.

Upon this a new company, the United States Electric Company, comprising many of the members of the local company, was organised in August, 1885, for the purpose of developing the system.

In June and July of 1886 the new company put down under contract 3,100ft. of an electrical railway upon the last plan, for the Denver Electric and Cable Railway Company. This track was laid on Fifteenth-street, between the Court House and the Post Office. Ordinary cross ties were used, upon which were strung 20lb. T rails. Notches were cut in the centre of the ties to form the conduit, and planks were spiked to the ties so as to cover the notches and to make the slot. The edges of the slot were protected by strap iron.

Under one of the planks was laid a Waring lead-incased cable of No. 3 B. and S. gauge. Circuit-closers were placed every 25ft., and the cable cut and attached to them. The two coaches built in Denver were placed upon the track. Each car had a motor of the Short type, made in Denver, and was supplied with both reversing gear and speed gear. Each motor weighed about 1,500lb. Tests were made of the efficiency of these motors when they were developing from 5 to 8 horse-power, with a current of 25 amperes, and they showed a return of 80 per cent. Our illustration (Fig. 4) shows a longitudinal elevation of one of the platforms of cars on a section of the new road bed and conduit.

On these cars these motors were placed on frames which were hung from the axles of the car trucks, and carefully insulated from them. On the armature shaft of each motor was placed a raw hide pinion. This pinion drove an iron gear on a counter-shaft, which had its bearings attached to the same frame. The counter-shaft carried another pinion, which meshed with the large gear of the driving axle of the car. This method of gearing was direct and positive, made little noise, and admitted of a simple and efficient reduction of speed from the motor armature shaft to that of the car axle. The small engiue and dynamo first placed in the plant were used to furnish the power.

On the 31st of July this road was started, and the car moved from one end of the track to the other without a mishap. This road was run constantly for three months, two men being required to operate it, one at the engine and one at the car.

In the meantime the Denver Electric and Cable Railway Company consolidated with another local company, and the new association took the name of the Denver Tramway Company. This company contracted with the Denver Tramway Construction Company for the equipment of its lines with the improved system. The work was immediately begun, and 3½ miles are now fully equipped and in operation with seven cars running. A new conduit of cast iron is used on this line and is shown in transverse section in Fig. 4. The slot is ⅝in. wide and the conduit is enlarged to 9in. by 12in., and is of substantial construction. A Brush motor is employed and the ordinary street car wheels and axles are provided with an iron frame supported upon spring pedestals upon which the motor is fastened. On the shaft of the motor is a pinion which drives a gear wheel on a short counter shaft; the latter again carries another pinion, which meshes with a large toothed gear wheel keyed to the axle of the car wheels. The greatest ratio between the pinion and the gear is 1 to 5, and hence very little noise is made. The car body and truck are each complete in themselves and are put together simply, so that cars that are now being pulled by horses can, without much expense, be adapted to the electrical system.

The conduit shown in Fig. 4 is so arranged as to admit of its being put down on existing horse-car lines. It is necessary to remove the pavement only in the centre of the track to dig a trench down to the cross-ties and to put down the cast-iron conduit, which is made complete in sections of 8 feet. Before the pavement is relaid, the lead encased cable is laid along at one side, as shown, all insulated and complete. The change from horses to electricity can be made in this way, without interfering with the regular running of the road.

The current which feeds the motor is used to light the cars with incandescent lamps, and to operate an alarm gong to warn persons of the approach of the cars. The latter can be moved backwards and forwards and governed from either platform.

Indicator cards taken from the engine while three cars were in service showed an average of 32 h.-p. delivered to the driving belt. A constant current of 40 amperes was passing over five miles of No. 3 B. and S. gauge conductor. The resistance of the circuit is 7 ohms; hence the circuit alone used 15 h.-p., which left 17 h.-p. for three cars, the friction of belting, shafting, dynamo, &c. This gives an average of 5·66 h.-p. for each car. One of the three cars, it may be added, was climbing a grade of 350 feet to the mile at the time of the tests, and it is safe to assume that it was using one-half of the power delivered to the cars. Hence each car can be run at the expense of 5 h.-p. delivered at the engine after the power necessary to overcome the line resistance has been deducted. It is estimated that a good Corliss engine will deliver 5 horse-power for one hour with the consumption of 15lb. of coal, or for 20 hours 300lb. will be required. Thus at $3 per ton the cost of fuel per car will be 45 cents per day. A constant expenditure of 15 horse-power will be required to send the current over the line. As this amount will not vary with the number of cars on the line, the cost for fuel for constant current on the entire line will be $1.50 per day. The conductor used in Denver, however, is too small. It was used first for 30 amperes, and was not changed when 40 amperes were adopted; hence the loss from this cause is abnormally large.—*The Electrical World* (New York).

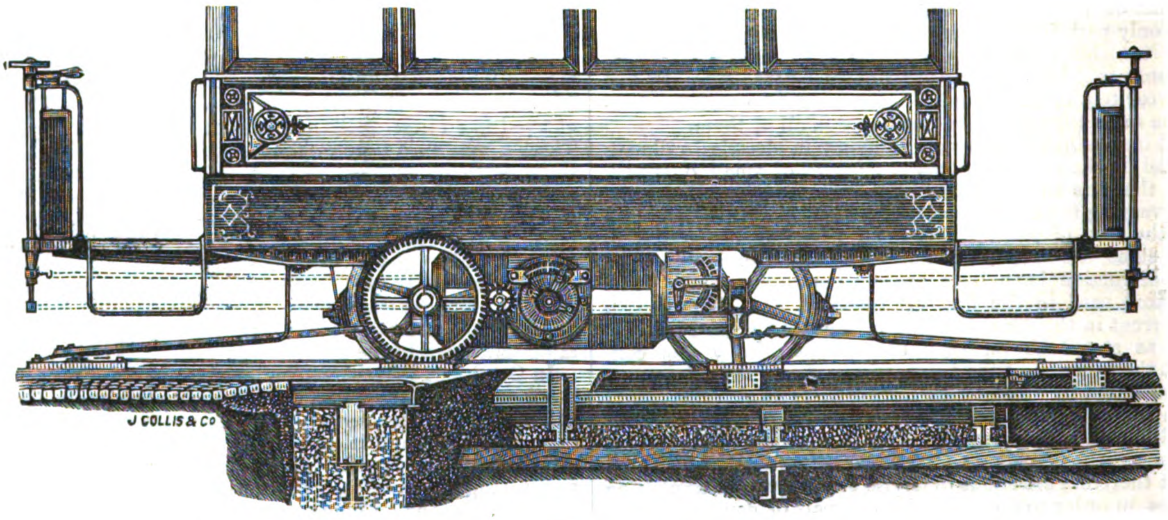

Fig. 4.

Railway Signals.—A simple and effective method of signalling the approach of a train at any required point has recently been tried in France. It consists merely of a large electro-magnet, which is placed on the line near the outer rail, and is connected by a wire with a trembling bell at the station. The passage of a train is found to create sufficient magnetic disturbance to ring the bell.

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THE DISTRIBUTION OF ELECTRICITY BY MEANS OF SECONDARY GENERATORS.

At a meeting of the American Institute of Electrical Engineers, held on Monday, the 15th ult., a discussion took place on the above subject, of which the following is an abstract:—

Mr. F. L. POPE said that in January, 1886, he went to London to examine the working of the Gaulard-Gibbs system at the Grosvenor Gallery, and felt persuaded that "there were great possibilities in the system, although it was not worked out practically at all—not worked out as we would work it out in this country by any means," the result being that the American patents were secured by the Westinghouse Company.

Dr. MOSES spoke enthusiastically as to the general superiority of alternating over continuous current dynamos, and ascribed their neglect during the last few years to unfounded prejudice brought about by one or two mishaps in earlier days. He felt confident that there would be no difficulty in adapting motors to work with alternating currents.

Professor ELIHU THOMSON said that he had made his first experiments with induction coils, in which the secondary consisted of large wire and the primary of fine wire, as long ago as 1877, when he succeeded in welding two copper wires by this means. He referred to the question of the efficiency of transformers in the following terms:—It always has appeared to me that there never could be any doubts as to the efficiency of a good induction coil. What is a dynamo machine but an induction coil after all. It is a revolving induction coil. We have what might be called the primary circuit in the field-magnets in the magnetism, but instead of reversing the current in the field-magnets we reverse the position of the secondary; that is, we turn it over to get our impulse; that is, not where those impulses come out as gushes of current or waves, but if we turn over a portion of the armature by degrees we get a continuous flow of current, and if the dynamo can be made to go to an efficiency of 90 per cent., why cannot an induction coil be made to go to an efficiency of 95 per cent.? We use a reverse primary. We do not reverse the position of our armature in relation to the magnetic field developed by the field-magnets, but we make our field-magnets reverse, and divide them up by laminations or by making them of fine iron wire. Put plenty of iron in the coil and the losses should not be any more in making the conversion, so far as Foucault currents or local currents in the iron are concerned, than they are in a well-constructed laminated armature. Referring next to the question of the supposed dangers of such currents Prof. Thomson expressed the opinion that, as a simple matter of fact, an alternating current was the safest form in which high potential electricity could be employed. He had twice over received a shock from an alternating current of high potential—in one case 1,300 volts, and in the other considerably higher—and in neither case were the consequences serious. He thought that, owing to the fact that the potential passed through zero value twice in every alternation, an alternating current did not produce the cramping effect upon the muscles which generally renders it impossible to leave go a conductor which has once been grasped while under a continuous E.M.F. of high value. [We are afraid that common experience with the so-called medical coils is decidedly against the Professor on this point.] He considered that the continuous currents which were employed in arc lighting, as a rule, underwent far *more rapid* fluctuations than those of the alternating currents usually employed, and that it was the abruptness of such fluctuations (combined with the self-induction of the circuit) which constituted the danger of arc lighting currents. For the same reason the so-called continuous currents interfered with the working of telephone lines far more seriously than did an alternating current. In the latter case the rythmical rise and fall of the current produced a musical note in the receiver, which did not really interfere with conversation at all. The arc lighting current, on the other hand, with its continual and jerky changes, gave rise to a continuous succession of crackling sounds which often rendered speech impossible. By taking care to keep the outgoing and return wires as close together as possible, the inconvenience was, however, in either case, reduced to a minimum.

Mr. WETZLER referred to a pamphlet issued by Messrs. Siemens and Halske, of Berlin, in which it was denied that the use of transformers effected any appreciable economy in the cost of central station lighting, except when overhead wires were permissible. They also stated that no transformer yet devised effected the regulation of the potential closer than 4 per cent.

Mr. C. O. MAILLOUX considered that the reason why a transformer was more efficient *per se* than a dynamo was because it had no "dead wire." He also referred to the effects of static charge.

Prof. ELIHU THOMSON replied that the reason why a greater E.M.F. was obtainable from a given length of wire in a transformer than the same length in the armature of a dynamo was to be found in the greater rapidity with which the lines of force passed through the wire in the case of the transformer. He thought it desirable to guard against the effects of static discharge by connecting the secondary coil to earth at one point, but he himself had taken the discharge of three Leyden jars, each of one gallon capacity, at a striking distance of 1½in., and was none the worse for it.

Mr. LEE CHURCH, replying to the criticisms contained in the pamphlet of Messrs. Siemens and Halske, said that the proof of the pudding was in the eating, and if they found that transformer systems paid in practice no amount of argumentative discussion would convince them to the contrary. Mr. Church proceeded as follows:—From the commercial standpoint, copper is not the sole element of economy by any means. In fact, I think there has been an injustice done to the secondary system by insisting that its prime usefulness lay in the reduction of the first cost of primary wiring. That is one way to put it; I think it is the least forcible way. As I judge of it, from daily contact with it commercially, the usefulness of this system lies in simply extending your business from a given point to the remotest point possible. We have certain fixed expenses—I am now talking to you from the standpoint of the man with whom I deal—these expenses consisting of salary accounts, and investments in building, and interest and depreciations, and what not. Now I wish to thin out that expense as far as possible, and to make it bring me in a large amount of business. Therefore, if it were true, which, permit me to state, it is not, that the increase of the cost of copper was in any such ratio as has been alluded to by Dr. Siemens, it still would leave untouched the fact of rendering the other fixed expense of the installation available for the increase of business. That fact has been commercially proved with us beyond peradventure. The use of the generator system—high potential system—permits the running of wires on a very small percentage of drop of E.M.F. With the ordinary multiple arc system and low potential our copper is so much anyhow that we have got to sacrifice 10 or 15 per cent. of drop to secure a reasonable amount of copper at all. But this converter system enables us to run upon a 2 two per cent. loss in the primary coil, and that saving is a merchantable article in some form in any way you are of a mind to figure it up. Furthermore, it has an enormous effect upon the light of the lamps, which is another commercial question. The secondary system enables you to maintain an almost absolutely uniform potential all over your line.

Mr. MAILLOUX and Mr. MANSFIELD each expressed some degree of scepticism with regard to the practicability of running motors with alternating currents, and the debate was concluded by Prof. ELIHU THOMSON in the following terms:—As to the motor question, I think that the alternating current motors can be made to run nearly as efficiently as continuous current motors, and with the saving of drop in the mains we can afford to run them less efficiently. It is not absolutely necessary to change the high potential current by an induction coil for the motor. If the motor is built to stand the potential in the main circuit there is no need of reducing the potential.

Mr. CHURCH: Except as a matter of personal safety.

Prof. THOMSON: That is all. But it seems to me that as the alternating current motor is an apparatus that has not got a commutator necessarily, the machine may be boxed up and run with fair safety. The only difficulty about running motors is getting them started. The fact is that if the impulse comes at a certain rate, unless the motor takes that impulse at the same rate it will not start—that is, you must give it the speed first, you must put it in tune with the rest of the circuit by giving it the speed, then clap on the current, and it will run at that speed absolutely. If you overload it you will draw it down and it will stop. Now, I have in my possession a little machine which, put on an alternating current circuit, will start from the state of rest and run right up developing considerable power. That machine may not be as efficient as the continuous current motor; but I can put that little motor on the same shaft with the larger motor and give it the speed of that little motor. I thus have the whole thing under my control. I take off the load from the motor, and I put this little motor on and I put the larger motor off, and then throw the current on and throw off the other. I am not at liberty to describe in full that arrangement. As yet it is not fully developed, but I hope before long to have it in such a shape that it can be fully discussed.

PHYSICAL SOCIETY.—April 23.

Prof. W. G. ADAMS, Vice-President, in the chair.

The following paper was read among others:—

Note on Magnetisation; on Sequences of Reversals, by R. H. M. BOSANQUET, M.A. Some experiments have recently been made on an iron bar whose magnetic properties, under reversals, with ascending values of current, were first determined some years ago. The magnetic resistances have again been determined, first with ascending values of current and afterwards with descending values. In all cases the induction was measured by reversing the current. The results generally show a greater magnetic resistance for descending values of current, except for small inductions, where the resistance was less when the experiments were performed in the above order. The paper concludes with a molecular hypothesis to explain the above results.

COMPANIES' MEETINGS & REPORTS.

Indo-European Telegraph Company (Limited).

The twentieth ordinary general meeting of the members of this Company took place on Monday at Winchester House, 50, Old Broad-street, under the presidency of Colonel James Holland.

The CHAIRMAN: Gentlemen, there being a sufficient number of shareholders present, either in person or by proxy, I declare the meeting duly constituted, and I call upon the Managing Director to read the notice calling the meeting.

Mr. W. ANDREWS (Managing Director) read the notice.

The CHAIRMAN: Gentlemen, I have before me the register of our mem-

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bers, and I put the question to you whether or not the seal of the Company shall be affixed thereto? I beg leave to do that *pro forma*.

The seal was then affixed.

The CHAIRMAN: Gentlemen, I have now to submit the report of the Directors, and the accounts appended thereto, for the year ended 31st December last, and to propose that they be taken as read. I presume, as usual, that has your concurrence.

The report and accounts were taken as read.

The CHAIRMAN: I therefore move, gentlemen, that the report and accounts be received and adopted.

Mr. H. WEAVER: I beg to second that.

The CHAIRMAN: Gentlemen, before putting it to the meeting I have to trouble you with one or two remarks, which probably you would like to hear, upon the substance of the report. First of all, with regard to the current charges. They are, with one exception, almost similar—practically similar—to those of last year, and require no special notice. The one exception is, I am glad to say, a favourable one—that is to say, that the maintenance charges are upwards of £1,567 less this year than last year. Considering the line has been kept in perfect order, I may say, during that time, I think that that is a very satisfactory item (hear, hear). At the same time I would caution you not to suppose that because for the last three or four years year by year there has been a reduction in the maintenance charges, that is to go on for ever. We take the greatest pains in keeping the charges down, but it is absolutely necessary to our credit, and character, and position that we should keep the line in the very best possible order. To do that requires at all times considerable care and considerable expense, and it is quite possible, therefore, that the outlay may be more or may be less. All we can say is that we will not spend more than is necessary for keeping the line in the perfect state—I may call it the perfect state—it is in at present. The next item is the receipts. They are £11,567 less than the receipts of the preceding year, and I would refer you to paragraph 8 of our report for 1885, which will account to you for the reduction in the receipts. We stated then, "The large augmentation of revenue is quite exceptional, owing to the total interruption of the Eastern Company's line for three weeks, the disturbances in Burmah, and the Afghan frontier question; and it is satisfactory that the £18,000 of additional revenue has only occasioned an increased expenditure of £1,600." So you will see we derived that year practically more revenue than we had any right to expect. It was the consequence of the accident to the Eastern Company's cables which threw an exceptional amount of business into our hands; so that although £11,567 looks a large reduction, nearly all of it being in the last half, after rates were reduced, it is really less important than might have been the case under different circumstances. And notwithstanding that reduction and falling off of late in the trade, it is a very pleasurable duty to us to be able to declare a dividend of 10 per cent. and place £10,000 to the reserve fund. I do not think any shareholder will be disposed, considering the exceptional state, and the long-continued exceptional state, I am bound to say, of Continental politics, to question that it is only prudent on our part to keep up a sufficient reserve fund (hear, hear). Now, I spoke at an earlier part of my address about the *quasi* perfect state of our line. We could carry, I will not say how many more messages than we do. It has such capacity that were many times the number of messages to come to us that actually do, we could carry them with celerity. Unfortunately we do not get the business; but the average speed for the past year, if we turn to the line which is worked by and belongs to this Company—that is rather the larger half of the whole—our average time has been 21 minutes. Now, the messages take nearly two hours on an average to arrive from India, and were the Indian Government departments and the management of their lines equal to ours, instead of being nearly two hours, or, rather, one hour and three-quarters—the total average time from India to London—it would only be 40 or 41 minutes. This is what we have done to improve Indian communications, and it is no small service to the two countries. We have no right, and no desire—far from it—to blame the Indian Government, for after all, although by comparison we do better, the Government departments do their work well. Still, they do not come up to the standard which, under the careful and skilful management of Mr. Andrews, has been attained by and kept up on our own line, although they compare favourably with most [hear, hear]. I wish with all my heart that the Indian departments could stir themselves to do a little more; but it involves expense, and expense is a matter which the Indian Government is unwilling, with demands on all sides, at the present time of all times to incur. But I mention this as a fact—a fact which should be known—that we do our portion of the work under a little more than 20 minutes, and our line, owing to the improvements effected, has a practically unlimited capacity for carrying messages. We have, as stated in the report, after prolonged negotiations with Russia, prevailed upon the Russian Government to give us the privilege of carrying certain South Russian messages, which, according to agreement with various Governments, we have no right to claim. Well, the Governments, looking at the capacity of our line, have conceded the privilege, and although the tariff is not very handsome, still, whatever we get is a benefit. They may, of course, at any time withdraw the privilege; but as long as we show the ability to carry Indian messages with the greatest possible ease and celerity, it is not likely they will withdraw it. From the 1st of July last year we reduced our rate. Everybody said, as is always the case in all companies I have individually ever had any connection with, "If you want increased business reduce your rates; you will bring in large numbers who never thought of sending messages before." Well, we reduced our rates, and 7d. per word is really a serious reduction, and we had some right to expect that we should get an increased number of words; but it so happens, I am afraid from the dulness of trade (for so we are told in every quarter), not only are we now getting much less money for the past few months than the corresponding amount for 1886, but the number of words is very much reduced also. All we can hope for is that trade may improve, and become brisker. We are an adjunct and aid to trade, and if traders have not active business many messages will not be sent. We have nothing to do but to look with patience to coming improvement in trade, which many people speak of, but which as yet we have not felt, and hold ourselves ready to deal with it when it comes. The only portion of the traffic worked by our line, in conjunction with the Eastern Telegraph Company, where any improvement is visible at present is Australia. There things are beginning to look brisker and better; in other quarters there is a decline. Well, gentlemen, I have no further remarks to make, but if any questions are asked I am ready and anxious to reply (cheers). I will now put the motion to the meeting. It has been moved and seconded that the report and the accounts appended thereto be received and adopted. Those in favour will please hold up their hands.

The resolution was carried unanimously.

The CHAIRMAN: Gentlemen, I have now to move that a dividend be, and is hereby, declared for the half year ended 31st December, 1886, of 17s. 6d. per share, making with the interim dividend already paid 6 per cent. for the year, and a bonus of 20s. per share, both free of income-tax, making 10 per cent. for the year.

Major-General G. B. TREMENHEERE, R.E.: I beg to second that.

The resolution was carried.

The CHAIRMAN: Gentlemen, I have now to state that in accordance with the provisions of the Articles of Association the following Directors retire by rotation:—Major-General G. B. Tremenheere, R.E., and J. Herbert Tritton, Esq., and offer themselves for re-election. I move that these gentlemen be, and are hereby re-elected, Directors of the Company.

Mr. C. W. EARLE: I beg to second that.

The CHAIRMAN: Gentlemen, in moving that, it would be really an impertinence on my part to attempt to make any laudation of these two gentlemen, who are now before you. Mr. Tritton's name is as well known in the City and as highly respected as that of any man living; the other Director, General Tremenheere, was one of the original Directors, and a more painstaking and honourable man cannot be found (cheers). I have, therefore, great pleasure in moving their re-election.

The resolution was carried.

Major-General TREMENHEERE: I beg to thank you for the resolution which you have so kindly passed.

Mr. J. HERBERT TRITTON: I also beg to thank you, gentlemen.

The CHAIRMAN: I have to state that the auditors, Messrs. C. F. Kemp, Ford and Co., retire, and offer themselves for re-election. I will ask some shareholder to be kind enough to move and second that.

Mr. STEFFEN: I beg to move that Messrs. C. F. Kemp, Ford and Co. be re-elected auditors.

Mr. GOUGH: I second that.

The resolution was carried.

The CHAIRMAN: That, gentlemen, terminates the business; it has been very short, and I hope you will consider it has been sweet.

Mr. STEFFEN: I propose that a vote of thanks be recorded to our Chairman for presiding. He has so clearly stated the matter before us that I think a vote of thanks is well due to him.

Mr. GOUGH: I have great pleasure in seconding that.

The resolution was carried.

The CHAIRMAN: Gentlemen, I may venture to assure you that I have great pleasure in thanking you for your patient attention to my remarks, and the courteous way in which you have been good enough to notice the exertions of the Directors.

The proceedings then terminated.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

The twenty-seventh ordinary general meeting of this Company was held on Wednesday last at Winchester House, 50, Old Broad-street, under the presidency of John Pender, Esq.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting.

The CHAIRMAN said: Gentlemen, I shall now go over the figures so as to bring them more immediately before you before making a few remarks upon the events of the last half year. The gross receipts for the half year amounted to £216,956, against for the corresponding half year of 1885 £247,016, or a decrease of £30,060. This loss of revenue arose principally from depression of trade, but it was also owing to the reduction of tariff which came into force on July 1st, and from which source alone a loss of £25,000 for the half year was anticipated. It is satisfactory, however, to note that nearly the whole of the decrease occurred in the first three months of the half year, the revenue for the last three months being almost equal, notwithstanding the reductions of tariff, to that of the corresponding period of 1885. Since the close of the year the traffic has shown an increase over the corresponding period of 1886. The working expenses for the half year have amounted to £80,066, against £71,473 for the corresponding period of 1885, showing an increase of £8,593, which is accounted for by an increase of £3,400 in connection with repairs to cables; increased amount for depreciation of ships, £750; renewal of land lines at Singapore and Banjoewangie, £2,000; electric light installations at various stations, £1,200, and other exceptional items. One interim dividend at the rate of 1¼ per cent. has been paid for the half year, and it is proposed to distribute another for a similar amount, together with a bonus of 2s. per share, payable on the 28th April, making with the interim dividends paid for the first half a total payment of 6 per cent.

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for the year 1886. The balance of £38,550 has been carried to the general reserve fund, which now stands at £569,440, as shown by the following figures :—Amount of fund at end of 1885, £565,644 ; interest added during 1886, £18,492 ; balance of revenue, £38,550 ; total £622,686. Less cost of Singapore-Penang cable charged to reserve, £53,245 ; leaving a balance of £569,440. The net result therefore, is that the reserve fund has been increased by nearly £4,000—the Singapore-Penang renewal cable paid for out of revenue—and 6 per cent. distributed amongst the shareholders for the past year. It will be observed that a further drawing of 108 of the Company's 5 per cent. debentures (1880 issue) took place on the 30th ult., the numbers of which are annexed to the report. The maintenance ships have been engaged on numerous repairing expeditions, but no serious interruption has occurred during the half year under review, beyond the simultaneous breakdown of the Indian-Penang cables, which was fully referred to at the last general meeting. Now, gentlemen, I have placed before you to-day what I believe to be, under the circumstances, a very fairly satisfactory account. When I last had the honour of addressing you, I mentioned that we were then looking at rather startling and depressing figures. It is curious that from the time we made arrangements at Berlin to reduce the tariff, somehow or other the trade fell off at the same time, so that things looked rather gloomy. But in spite of this there has been a steady increase in telegraphic communications. The hope I then held out to you was that at the time I next met you I should probably be able to put before you a better account, and I think I have done that to-day. We are now paying you for the past year 6 per cent., against 7 per cent. for the previous year, and if the Company's prospects continue to improve I think we shall be able to revert to the 7 per cent. When I last addressed you I referred to a dispute that existed between the New Zealand Government and the Company respecting the renewal of the New Zealand cable subsidy, which led to a rather warm discussion, the end of which was that, I believe, we secured the support of the Australian colonies and the press, and the approval also of a very large number of the New Zealand people. We practically gained the battle ; but you know there is no use continuing to contend with a Government. We felt that the action of the Government was causing very serious inconvenience not only to the telegraphing community of New Zealand, but also to our other colonies, and we decided therefore, upon the advice of Sir Dillon Bell, the Agent-General in England of New Zealand, to adopt the *status quo ante* for six months, when the whole question would be brought before the Parliament of New Zealand. The Parliament is now just about to meet, when we hope that the broad, liberal, and generous course that we adopted at that time will be appreciated by the Colonial Parliament, and that they will do us justice. I hope when we meet you again that this question will be satisfactorily arranged, and, in short, friendly relations resumed. You are probably aware that at the present time there is a Colonial Conference being held in London. The representatives of the colonies there, I may say, are the cream of colonial society. They are sent here with a view to drawing closer the relations between the mother country and the colonies. I have always held that nothing has more contributed to the progress—material and political—of those colonies than the establishment of telegraphic communication with the mother country. I believe the delegates fully appreciate that ; but they appreciate it to an extent beyond what we think in our interest right and good. They have derived such advantages from the use of the cables we have laid down, that probably some of them would like additional ones. We are prepared to prove to them that there is no company which could give them the same advantages we could. We can give them lower rates than it is possible for any competing company to establish. We believe we have now, not a monopoly, but such a wide-spread system that it is impossible for private enterprise to compete with us, because, in the first place, we can do the work cheaper than they can, and in the second place there is no necessity for any competing cables, because we can do a great many more times the work than is required of us at present. Some of you may have observed lately a statement in the *Pall Mall Gazette*, showing the advantages of an opposition line. The gentleman who wrote that article, and who is posing now as a great apostle of telegraph reform, made a statement to the effect that a one shilling tariff from England to Australia might be established, and that it would pay well. That, gentlemen, I thought scarcely worth taking any notice of, but still, when a man writes who is ignorant of the subject, people who do not understand the question are apt to believe what he says. We who know the whole of the circumstances know how absurd the proposition is. The out payments alone at the present low tariff across the Atlantic would amount to at least 1s. per word, but it is probable that before long the Atlantic tariff will be increased, in which case the out payments will probably be 2s. per word. That shows the absurdity of the whole thing. I think those people who know the subject well, and even the people whom he is now working with, must see that his advocacy does them a great deal more harm than good. Therefore, I say that if the opposition is to take the form of, and is led by, private enterprise by the gentleman I refer to, I think we may all go to sleep without any very great anxiety in regard to competition. Gentlemen, I have come a great deal into contact with the delegates to the Conference, and they are, I believe, deeply impressed with the responsibility of their mission. I can see that there are very important interests to be settled; but our interest is a very important one also. I am not without hope that we shall come to an arrangement with them, at all events, that will make opposition impossible, or if opposition should come, it must come in such a form that the Governments must deal with our system also. I think I may say that our position is a strong one. I believe that we should receive full justice from the Imperial Government. I have also every reason to believe the colonial Governments recognise that we have been the pioneers of the vast existing system which has so materially assisted in the enormous development of trade in the colonies, and having that belief, and remembering that we are dealing with men who understand our position, and who are anxious to reduce as far as possible the tariffs between the two countries, we may look for a favourable result. Your interests will be very carefully watched, and I am not, I think, too sanguine when I say that I have no reason to believe for one moment that they will suffer. With these remarks I beg to move the following resolution :—

"That the report and accounts of the Directors now submitted be received and adopted, and that a dividend be now declared of 2s. 6d. per share, together with a bonus of 2s. per share, both free of income-tax, payable on the 28th instant, making, with the previous distributions, a total payment of 6 per cent. for the year 1886."

Lord MONCK : I second the motion.

The CHAIRMAN put it, and it was carried unanimously.

Lord MONCK then proposed the following resolution :—"That John Pender, Esq., who now retires by rotation, be, and is hereby, re-elected a Director of this Company."

The Marquis of TWEEDDALE seconded the motion, which was carried unanimously.

The CHAIRMAN : I am very much obliged to you for the honour you have done me in re-electing me as one of your Directors. I can only say that the interest of this Company has been more or less a hobby of mine in the past, and I hope it will continue to be so as long as I have health and strength given me. The next resolution is :—"That George Garden Nicol, Esq., who now retires by rotation, be, and is hereby, re-elected a Director of this Company."

Sir JAMES ANDERSON seconded the motion, which was carried unanimously.

Mr. NICOL having acknowledged the compliment,

The CHAIRMAN said the next resolution would be proposed by Mr. Griffith.

Mr. W. GRIFFITH accordingly proposed the following resolution :—"That Mr. Henry Dever and Messrs. Quilter, Ball, and Co. be, and they are hereby, re-elected auditors for the ensuing year, at a remuneration of £100 each." He said : Following the example of those who have preceded me, I will not trouble you with any long remarks. I will merely say that these gentlemen have served us for many years, and served us so well that it is a good reason for re-electing them to their office.

Mr. PEPPER seconded the motion, which was carried unanimously.

Mr. GEORGE HIRON : If that concludes the business, it becomes us to move a vote of thanks to our worthy Chairman and the Board generally. I think, after the very satisfactory explanation he has given us of the position of the Company, we should agree to that. There was some little doubt, some six or twelve months ago, of some new cable being started, and that by a rearrangement of the terms for carrying the messages we might suffer a diminution of dividend. Fortunately, the diminution has not been what we anticipated—at all events, the Chairman has said that we get 6 per cent. for the past year, and that before we pass another year over we may possibly be in a position to receive 7 per cent. I think it may be very interesting to the shareholders present, and also to those who are absent, to think that harmony is maintained in connection with this new movement from the colonies. We see that the colonial representatives are over here, and I had supposed that it was with the view of getting the thin edge of the wedge in, to get a new cable or to lower our rates. Our Chairman, who is the representative of the Board at the conference, is fully able to deal with that question in a manner which will be satisfactory to us all. I am quite sure that we can leave our interests in the hands of the Directors with every confidence that the result will be satisfactory when the conclusion of this arrangement takes place. There is one matter that I should like to mention. I think it is quite time that this proxy business were done away with. You send out proxies for every meeting we hold. We all know the object of sending them, namely, to enable the Directors as a rule to possess the proxy power against persons who might be antagonistic to the views of the Board or the interests of the Company. I do not think there is any doubt among us that the Board, which is composed of gentlemen of integrity and honour, would place such a resolution before us that would create such a feeling, and that if they were to do so it would not be passed by the shareholders. I have attended the meetings frequently, and I have never seen the necessity for exercising the use of proxies, and I do not believe it will ever be necessary.

Mr. KING seconded the motion, which was carried unanimously.

The CHAIRMAN : I am very much obliged to you, and I thank you sincerely on behalf of my colleagues and myself for your renewed expression of confidence. There is no doubt that your interests are in good hands. I have been to-day for a couple of hours at the conference, but I am forbidden to open my mouth as to what passed. All I can say is this—that the Governments are now recognising the great position which these telegraph companies hold, and are also disposed on important occasions not only to consult the Companies, but to give them an opportunity of expressing their views on any question affecting this large and extended system of telegraphy. Therefore, I think we are, even with the conference, in a position to see that no harm is done, and that we are probably also in a position to see that a great deal of good may come out of the discussions thereat. In regard to the proxies, we do not issue them at the expense of the shareholders, but I would just say as a matter of right one word in favour of absent shareholders. We have nearly 5,000 shareholders. Look round this room at the attendance. Would it be right or fair of us, in whom the shareholders have perfect confidence, having regard to attempts which might be made by men who are interested in getting up competing companies, and totally opposed to your interests, to allow ourselves to be taken by surprise at a small meeting like the present? In a small meeting it would be a very dangerous thing if the interests of the absent shareholders, many of whom live in Ireland, as well as those present, were not

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protected by the proxies of the majority of the shareholders. We do not compel shareholders to return the proxies to us. We only invite them to do so if they have confidence in us—and they have shown that confidence in the past by returning a large number. We have, however, never used them. We have never voted against a meeting at any time in my recollection, and we never intend to do so if we can avoid it. But your interests, and your interests alone, we are bound, as Directors, to take every precaution to protect. These are my views about proxies. They cost the shareholders nothing. It is a question now asked at almost every public meeting in London. Having expressed my views, I believe that every sensible man—even the gentleman who spoke just now on the subject—will agree that the position we have taken in the matter is the right one in the interest of all honest, well-intentioned shareholders. I beg to thank you, gentlemen.

The proceedings then terminated.

Reuter's Telegram Company (Limited).

Colonel James Holland presided on Wednesday over the thirty-third ordinary general meeting of the shareholders in this Company, which was held at the offices, 24, Old Jewry.

The SECRETARY (Mr. F. J. Griffiths) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, no doubt you will take the report as read. You see it is a very brief one, as is the custom with Reuter's Company. We merely state the leading facts, and I am very happy to be able to congratulate the shareholders generally and ourselves that the predictions which I ventured to make at our last annual meeting—which was rather a sorrowful one—have been borne out, and we are able to declare a dividend of 7½ per cent. for the year, and to place a substantial sum to the reserve fund. Those are the leading facts, and they are very satisfactory ones. With respect to the accounts, I may observe that the sundry creditors and the sundry debtors balance each other, and that they have substantially run off. There are a few agents' balances, which are floating balances, and we have nothing in our accounts to indicate anything like bad or even doubtful debts. I believe the Company was never in a sounder state than it is at the present time, and it is an extreme satisfaction to us to be able to reinforce the reserve fund—to pay back a considerable portion of that which in less favourable times we had to borrow. You must bear in mind, with respect to our reserve fund, that it is stated expressly in the Articles of Association that the reserve was instituted for the purpose, among others, of equalising dividends. I merely mention that as giving the reason why at a former annual meeting we were unhappily obliged to borrow from it. Further on, looking down the accounts, you will see at a glance what is the cause of our greatly improved position since this time last year. The item of telegrams and agencies—the great source of expense, of course—amounted in 1885 to £72,159, and last year to £64,864. That is to say, they cost us very nearly £8,000 less last year than they did in the previous year. It is true, as a set off against that, there is a small diminution in the receipts for the telegrams. The cause of the great expenditure was war. Wars, and rumours of wars, are always damaging to our Company. There was war in the Soudan, Burmah, and elsewhere. We are always obliged when anything of great interest to the world at large is going on, to have well paid officials on the spot to telegraph the information to us, for the information, I may say, of the whole world. It was a very troubled year in 1885, and the cost to us was very great. Last year, though not altogether devoid of rumours of war and trouble, the cost was very much less. That fact, added to what I may term judicious liberality on the part of the Indian Government and the various telegraph companies to and beyond India of lowering their press rates to one quarter of the full rate, has been very beneficial to us, and has enabled us to give you a dividend, which I have no doubt you are glad to receive, and which we are only too happy to give you. I have really nothing else to say except to answer any question that may be put. I have now to move this resolution: "That the report and balance-sheet now presented be received, adopted, and entered on the minutes."

Baron DE REUTER formally seconded the motion.

The CHAIRMAN put the resolution, which was carried unanimously.

Admiral the Right Hon. Sir J. C. D. HAY, Bart., K.C.B., next proposed the re-election, as Director, of Colonel Holland. He had served under Colonel Holland on the Board almost since the commencement of the Company, and he could add his testimony to that of all who knew Colonel Holland of how ably he had fulfilled all the duties which the shareholders had entrusted him with.

Baron DE REUTER seconded the motion, which was carried unanimously, it being announced by Sir JOHN HAY that the Directors had reappointed Colonel Holland to the chairmanship of the Board.

The CHAIRMAN having acknowledged his re-election,

Mr. F. H. KEENLYSIDE moved, and Mr. LOVEDAY seconded, the re-election, as auditors, of Messrs. Quilter, Ball and Co. The motion was unanimously adopted.

Mr. KEENLYSIDE then inquired whether the Directors had made up their minds as to the sum at which the reserve fund should stop. Of course the reserve was a most desirable thing, and he was only too happy to see it grow. The rent they used to pay for their offices was £550 a year, the amount mentioned under the reserve fund account.

The CHAIRMAN: That was the rent, and we purchased the freehold. We then put to reserve fund what we used to pay for rent. At present we have not fixed in our minds upon any particular sum to which to limit the reserve fund, and for this reason. If you look to the accounts you will see that the goodwill of the Company is an asset of £65,000. We believe that to be a valuable asset, but until that is tested in the open market by our desiring to sell the business—which is not a very likely proceeding—no human being can say how much that will fetch. We therefore think it safer and better whenever we are in a position to give a fairly liberal dividend, to make some addition to the reserve fund, so that in case of need at any future time the goodwill account may be, to a certain extent, discounted.

Mr. KEENLYSIDE asked whether it was intended, if they had sufficiently prosperous years, to write down the goodwill.

The CHAIRMAN: We are hoping to write it down by degrees and in moderate amounts; but I may say that we have not made up our minds decidedly on any course of action. At present we are in that state that we think £1,000 added now and then is a desirable thing towards writing down the goodwill; but, as time goes on and circumstances develop themselves we shall be in a better position to say something definite on the subject. I have nothing further to trouble you with, but to declare the meeting ended, and to thank you for your attendance.

Mr. KEENLYSIDE proposed a vote of thanks to the Chairman and Directors for their able, careful, and judicious management of the affairs of the Company. When he first took shares they used to have 10 per cent., then they got down to 7½ per cent., and then, he was afraid, two or three years ago, as the Chairman had said, they had to draw on the reserve fund. They were now in a more prosperous state of things, and he had great pleasure in proposing a vote of thanks to the Chairman, the Directors, and the Secretary.

Mr. W. F. BRADSHAW seconded the motion, which was carried unanimously.

The CHAIRMAN: On behalf of my colleagues, and especially of our Managing Director and Secretary, to both of whom it is impossible to accord a higher meed of praise than they deserve, I have to return you our best thanks.

The meeting then separated.

The Oriental Telephone Company (Limited).

The seventh ordinary annual general meeting of this Company was held on Wednesday, the 27th April, 1887, at the City Terminus Hotel, Cannon-street, under the presidency of Mr. William Addison.

The SECRETARY (Mr. Alex. B. Chalmers) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: Gentlemen, in moving the adoption of the report and accounts, I think there is very little for me to say. You will observe that this is the first time we are able to show a profit on the working instead of a loss. The accounts for 1885 showed a loss of £1,600 for that year, while those for 1886 show a profit of £2,400, or an improvement of £4,000 during the year in our position. We have expended during the year £1,600 on capital account. That is for extensions of the exchange and private line systems. The greatest improvement has been in Rangoon, of which we shall get the benefit during the current year. The changes referred to in the last report in regard to Mauritius, have proved beneficial, and although the depression in trade still exists there which affects our interests, the exchange working shows a small profit of about £200, instead of a loss last year. The great drawback we have had is the liabilities to the Indian Companies in the shape of guarantees, which continue to press heavily upon us; but as the Bombay expires next September, and the Bengal Company in June following, we shall soon be relieved from that heavy burden. The change of systems at both these places has been completed during the past year from the Law system first erected to the improved magneto system. Of course this has incurred extra expense, but it became necessary as the exchange subscribers increased. The result in Bombay has been most satisfactory in bringing new subscribers. Bengal does not seem so progressive a place. Another hindrance to our paying a dividend is that the Egyptian Company, although earning a large income, has no working capital, the shares having never been allotted to the public. However, we think now our position looks brighter, and we hope the time is approaching when the question of paying a dividend may be taken into consideration; but I must tell you that before we can do so we must have the cash to pay it with, and not only be able to show it on paper. This, I think, we ought now to be able to do. I will explain our position in reference to the Egyptian Company. Their shares were not allotted to the public at the time of the formation of the company, which was necessary to give them working capital, but are held by this Company with a small exception. The result is that we have had to find the capital necessary for the construction and working of their lines. When we came into office that company was paying a dividend of 3 per cent.; since then it has steadily increased, and this year they have paid 6 per cent.; but, having no working capital, they are obliged to employ their revenue for constructions and extensions, and borrow the money from us. I think, however, now that company has arrived at so satisfactory a position, they ought to be able to place some of their shares, and if any of the Oriental telephone shareholders would like to take some, we think they will find them a good investment for themselves, and they will provide the Egyptian Company with a working capital which will set free that company's revenue, and enable them to pay us our dividend immediately it is declared. Previous, however, to any payment of dividend the Board purpose placing before the shareholders a plan for the re-arrangement of the capital of the Company, whereby the liability now existing on the shares will be reduced, for although a trading company requires a certain amount of uncalled capital for its credit, your Directors think the present liability of 9s. per share quite unnecessary.

Mr. B. ST. JOHN ACKERS seconded the motion, which was carried unanimously.

On the motion of Mr. ACKERS, seconded by Mr. THOMAS LLOYD, Mr.

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Addison was re-elected to his seat at the Board, which he duly acknowledged.

The Right Hon. G. A. F. CAVENDISH BENTINCK, M.P., then proposed the re-election of Mr. George Bland Frost as a Director, which was seconded by Mr. HENRY GREWING, and agreed to.

Mr. FROST, in acknowledging his re-election, reminded them that when he first joined the Board the affairs of the Company and its outlook were very unpromising indeed. The shares were down to 2s. 6d. just after the report of the Committee of Investigation. He was very pleased to say that they were now in a very much better position, and that they were within measurable distance of being a steady dividend paying Company.

The auditors (Messrs. Deloitte, Dever, Griffiths and Co.) were then, on the motion of the Rev. Dr. FINCH, seconded by Mr. ANGIER, reappointed, and the proceedings terminated.

The Equitable Telephone Association (Limited).

[The following report has been sent us by the Secretary of the Company.—ED. *E.*]

The first ordinary general meeting of the shareholders of this Company was held at 40, Queen Victoria-street, on Friday, the 15th inst., Mr. G. C. Warden presiding.

The CHAIRMAN intimated that counsel's opinion had been taken with regard to the freedom of the Company's instruments from the Bell and Edison patents with entirely favourable results, and that though every facility had been given to the United Telephone Company to contest the freedom of the said instruments they had taken no action in the matter. The Company were preparing now to place their instruments in the market, and anticipated a very considerable demand.

A report was adopted stating that more shares had been applied for than could be allotted, and that the calls had been duly paid on those issued.

The re-election of the retiring Directors brought the proceedings to a close.

The West Coast of America Telegraph Company.

Report of the Directors to be submitted to the tenth ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, E.C., on Tuesday, May 3rd, at 1 o'clock :—

The balance-sheet and revenue account for the year ending 31st December, 1886, show a gross revenue of £43,026. 13s. 1d., against £45,957. 10s. 10d., earned in the year 1885. The deduction of debenture interest and all other charges make the net balance of profit £11,037. 3s., and adding £739. 13s. 5d. brought forward from the previous year, the total sum to the credit of revenue account amounts to £11,776. 16s. 5d. Out of this the following dividends have been paid :—

In September, 1886 .... 2s. per share, £3,000
In January, 1887 .... 2s. ,, ,, 3,000 — £6,000

And the Directors recommend adding £5,000 to the reserve fund, making the latter £20,000, and leaving £776. 16s. 5d. to be carried forward. The falling off in the earnings of the Company is due to loss in exchange and depression of trade on the West Coast of South America during the greater part of the year ; however, a reaction seems to have commenced in the month of October last, and this, combined with an improvement in exchange, has since more than made up for the ground lost during the period under review. The working expenses of the Company show a small decrease upon the previous year. The cables and repairing steamer are kept in perfect working order. The members of the Board retiring by rotation are Mr. Thomas Fielden Campbell and Mr. Henry Roberts ; both are eligible, and offer themselves for re-election. The auditor, Mr. J. Weise, of Messrs. Turquand, Youngs and Co., retires, and is eligible for re-election.

CITY NOTES.

EASTERN EXTENSION TELEGRAPH COMPANY.—This company notifies that the coupon on their Five per Cent. Debentures (1880 issue), due on May 1st, will be payable on and after Monday next, the 2nd prox., at the Consolidated Bank, 52, Threadneedle-street, E.C.

GREAT NORTHERN TELEGRPAH COMPANY.—It is announced that Messrs. C. J. Hambro and Son will pay the excess dividend on this company's stock at the rate of 5s. per share.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 22nd inst. were £3,287.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th inst. are £2,410, as compared with £3,232 in the corresponding period of 1886. The decrease is owing to the interruption in the main cable, which was repaired on the 21st inst.—At a meeting of the Directors of this Company, held on Wednesday, it was decided to recommend to the shareholders at the approaching meeting that a dividend of 6s. per share be declared on account of arrears of dividend on the first preference shares.

NEW COMPANY.—The prospectus of the Singapore, Straits Settlements, and Siam Electrical Company is issued this week. The company is to be formed for the purpose of acquiring and working certain concessions already granted in Singapore, and for developing the electric light and the telephone in the far East. The capital of the company is £60,000 in 12,000 shares of £5 each. Further particulars will be found in our advertisement columns.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. April 27.		Business Done Week Ending April 27. Highest.	Lowest.
Anglo-American	37,	38	37¾	36½ xd.
Do. Preferred	58½,	59½	60¾	58½ xd.
Do. Deferred	14½,	15½	15¾	15
Brazilian Submarine	10⅝,	10⅞	10⅞	10⅝
Cuba	12,	12½	12½	—
Do. Preference	18,	19	—	—
Direct Spanish	2¾,	3	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	9,	9½	9⅜	9¼ xd.
Eastern Telegraph	10⅝,	10⅞	10⅞	10⅝ xd.
Do. 6 per Cent. Preference	13½,	14	14	13½ xd.
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	12¼,	12½	12½	12⅜
German Union	9,	9½	—	—
Globe Telegraph and Trust	5⅝,	5⅞	5 13-16	5 9-16 xd.
Do. Preference	12½,	12¾	12¾	12 7-16 xd.
Great Northern	13⅞,	14⅛	14¼	13 15-16
Indo-European	35½,	36½	36½	36
Reuter's	7½,	8	8	7⅝
Submarine	180,	190	—	—
West India and Panama	⅝,	⅞	—	—
Do. 1st Preference	9¼,	9¾	9⅝	9⅜
Western Brazilian	7¼,	7½	7 3-16	—
Western Union 7 per Cent. 1st Mortgage	123,	127	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¾,	⅞	13 16	—
Oriental	3-16,	5-16	—	—
United Telephone	13,	13½	13⅝	12⅞

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	3	—	—
Do. (fully paid)	3¾,	4¼	4¼	4⅛
Swan	1⅜,	1⅝	—	—
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	36,	37	36⅛	36
India Rubber, Gutta Percha, and Telegraph Works	22½	23½	23½	23

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY (Limited).

FIVE PER CENT. DEBENTURES (1884 ISSUE).

Notice is Hereby Given that in conformity with the conditions upon which the above Issue was made, the under-mentioned numbers of DEBENTURES were this day DRAWN at the Offices of the Company, 8, Great Winchester-street, in the City of London, in the presence of THOMAS FULLER, Esq., one of the DIRECTORS, RICHARD COLLETT, Esq., Secretary of the Company, and the undersigned Notary Public.

The said Debentures will be PAID OFF at par on the 31st July next, at the Alliance Bank, Bartholomew-lane, London, E.C., after which date the interest thereon will cease.

371 DEBENTURES OF £100 EACH, NUMBERED

1	170	308	457	648	791	952	1075	1227	1353
3	171	315	461	649	793	954	1077	1233	1354
4	174	321	471	653	802	955	1079	1245	1364
5	176	322	473	662	803	956	1085	1249	1365
6	178	324	478	663	807	960	1087	1251	1369
16	192	336	481	665	809	966	1109	1258	1379
17	193	342	482	666	812	970	1116	1259	1386
20	196	350	485	674	819	972	1118	1261	1389
26	203	353	486	675	821	973	1121	1262	1390
41	204	354	487	676	822	976	1125	1263	1391
44	209	362	490	677	825	980	1129	1264	1393
45	216	363	504	679	827	981	1131	1267	1395
51	217	368	508	680	835	984	1132	1271	1396
66	224	372	510	684	836	988	1137	1273	1398
72	231	373	514	686	848	995	1143	1275	1403
73	233	378	515	691	866	996	1149	1280	1416
78	237	384	523	693	867	997	1150	1282	1421
84	238	389	531	694	869	1005	1154	1283	1429
86	250	392	533	695	875	1009	1157	1291	1430
90	252	393	540	696	884	1010	1160	1293	1432
91	253	401	543	704	900	1020	1168	1295	1433
93	255	405	547	707	902	1023	1176	1297	1436
95	256	409	550	710	908	1025	1183	1302	1437
96	262	417	560	711	909	1030	1196	1304	1438
97	268	421	565	714	914	1033	1198	1306	1459
102	269	423	577	716	920	1034	1199	1307	1463
109	270	431	587	718	922	1037	1200	1310	1464
110	273	432	600	721	927	1043	1203	1314	1468
114	277	433	606	722	928	1048	1209	1316	1472
131	280	435	607	735	933	1049	1210	1322	1474
136	286	440	608	739	934	1057	1211	1325	1486
138	287	441	611	740	935	1058	1212	1329	1487
140	289	443	612	750	942	1059	1213	1334	1491
142	292	444	628	753	943	1063	1215	1335	1494
148	296	446	630	758	944	1067	1220	1341	1496
151	303	449	641	769	945	1070	1224	1349	1498
164	307	451	646	779	950	1073	1226	1351	1499
167									

For £100 Sterling each £37,100

By order of the Board,
RICHARD COLLETT,
Secretary.

Countersigned
W. E. VENN,
2, Pope's Head-alley, Cornhill, E.C.,
Notary Public.
London, 26th April, 1887.

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The Anglo-American Brush Electric Light Corporation

(Limited). Offices and Works: 112, BELVEDERE ROAD, LAMBETH, S.E.

TELEGRAPHIC ADDRESS: "MAGNETO," LONDON.

PATENTEES AND MANUFACTURERS OF APPARATUS FOR THE

BRUSH System of "Arc" Lighting, which is the only one which has stood the test of years of hard work, and by which an extended economical lighting is rendered possible.

BRUSH-VICTORIA Compound-Wound Self-Regulating Dynamos, as supplied to Her Majesty's Naval, Militar and Civil Departments.

BRUSH-VICTORIA Incandescence Lamps, with the new pure homogeneous filament.

BRUSH-SELLON "Arc" Lamps, for outdoor and indoor lighting, to give a pure, steady, and unvarying light.

BRUSH CARBONS have been further reduced in price, and are now not only the cheapest carbons to burn but the cheapest to buy in the market.

VICTORIA Self-Regulating Electric Motors, for Tramcars, Launches, Hoists, Rock Boring, Pile Driving, &c. These motors form the most efficient and economical means of supplying power in any situation not conveniently accessible to steam power.

The process of manufacture known as COMPOUND WINDING is covered by Patent No. 2003 of 1878, granted to Mr. H. J. Haddan as agent for Mr. Charles Francis Brush, which patent is the property of the Anglo-American Brush Electric Light Corporation. The public are warned against purchasing any compound wound dynamo electric machines other than those manufactured by the Corporation or their licensees.

The Corporation are prepared to furnish, on application, estimates for Electric Lighting of every description, public and private, and also to carry out complete installations of the Electric Light in the Metropolis and elsewhere.

The Corporation are now prepared to supply and erect Electric Lighting Plant on the Purchase Hire System. Full particulars on application to the Secretary.

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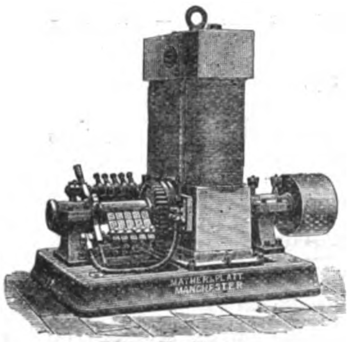

Edison-Hopkinson, GOLD MEDAL, 1885.

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Slow-speed Dynamos for Ship Lighting.

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ELECTRICAL RAILWAY PLANT.

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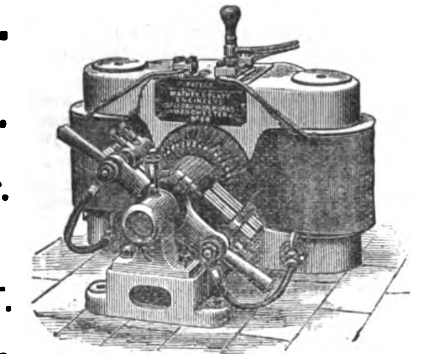
High-speed Engines with Automatic Cut-off.



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CARRY OUT INSTALLATIONS OF ALL SIZES FOR THE

Electric Lighting of Churches, Chapels, Schools, Public Halls, Factories, Streets, Offices and Private Residences,

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NOTES.

POSTAL TELEGRAPH APPOINTMENT.—Mr. A. Hunter, telegraphist in Edinburgh, has been appointed postmaster at Leven.

RHEIMS.—The extensive wine cellars of the Maison Pommery at Rheims are to be provided with electric light by the gas company of the city.

BRUYÈRES (VOSGES).—The town of Bruyères is to be provided with a central electric lighting station, power being obtained from the River Arentelle.

COCKERMOUTH.—The National Telephone Company have opened an exchange at Cockermouth, which is also in connection with the company's West Cumberland trunk lines.

BORDEAUX.—At Bordeaux it is stated that the proprietors of twenty-five cafés situated in one quarter of the city have clubbed together to provide themselves with electric light from a central station.

SAINT-AIGNAN (LOIR-ET-CHER).—On the 27th March a central electric lighting station commenced operations in this town. The streets are lit by incandescent lamps, and provision is made for lighting a small number of private houses.

ELECTRIC LIGHTING AT GRIMSBY DOCKS. — It has been decided to introduce the electric light into part of the Grimsby Docks, and the order for this work has been given to Messrs. Drake and Gorham, 2, Princes-mansions, Victoria-street, S.W.

INTERNATIONAL TELEPHONY.—A convention has been concluded between the Governments of Austria, Switzerland, and Bavaria, for the establishment of telephonic communication between the frontier towns of Bregenz, Lindau, and Rorschach.

FOLKESTONE.—ESTIMATES WANTED FOR ARC LIGHTING.—The Folkestone Town Council resolved, on Monday last, to obtain estimates for lighting "The Lees" by electricity. "The Lees" is a promenade on the sea front, about one mile in length. The present cost of lighting by gas amounts to £284 per annum.

THE STOCKHOLM TELEPHONE EXCHANGE.—In a recent note we referred to the rapid strides which the use of the telephone is making in Sweden. The business of the telephone exchange at Stockholm is increasing to such an extent that it has recently been found necessary to establish a new central office, with improved apparatus, designed for 4,000 circuits, but capable, if required, of accommodating as many as 7,000.

HEREFORD.—At Mynde Park, near Hereford, on the occasion of the coming of age of Mr. T. R. Symons, a decorative installation of an extensive and elaborate character was carried out by Mr. Arthur Shippey and Mr. Symonds, of Hereford. The work was commenced at mid-day on Monday, and, including the fixing of an engine and dynamo, was completed by the Wednesday evening. A pretty effect was produced by floating coloured lamps upon the lake. These lamps were supplied with current from Woodward's small portable accumulators.

THE TELEGRAPH IN THE WEST HIGHLANDS.—Among the recommendations contained in the report of the late Crofter Commission was one to the effect that postal and telegraphic communication should be extended and improved in the highlands and in the islands of the west coast. The crofters in the district of Airisaig have recently forwarded a memorial to the Postmaster-General, asking that in view of this report telegraph offices should be opened at Moidart, Airisaig, Morar, and Knoydart, and that the guarantee usually required should, under the circumstances, be dispensed with.

ST. JAMES'S HALL.—St. James's Hall was lighted on Monday night by electricity for the first time. The light burst forth (says the *Pall Mall Gazette*) in the most sensational way just at the close of Liszt's Rhapsodie Hongroise, No. 3, when the room broke out into applause. Owing to some technical imperfection, the insurance company, it seems, were not satisfied, and so the electric lamps could not be used at the beginning of the concert. The gas heat was therefore in full play nearly all through the programme, and we must wait for another night before pronouncing, as we shall hope to do, on the improved state of the atmosphere.

GAS EXPLOSION IN A TELEGRAPH PIPE.—Shortly after two o'clock last Friday afternoon some men in the employ of the Post Office Telegraph Department struck a match to repair the underground telegraph wires outside the Villiers-street end of Charing-cross Station. Immediately they did so a loud explosion was heard outside No. 15, Strand, about thirty yards from where they were working, which forced two large stones bound round with iron and weighing about 1cwt. each, a distance of six or seven feet. Fortunately no one was hurt. The explosion was due, it is stated, to gas entering the telegraph tubes from a leakage in a gaspipe underneath the pavement.

WINTER'S BLOCK SYSTEM.—We have received a pamphlet containing a description of a modified and improved system of block signalling, designed either for single or double line working. This system is the invention of Mr. G. K. Winter, M.S.T.E., telegraph engineer to the Madras Railway, and was designed primarily to meet the requirements of the Indian railways. The apparatus carries out the general principle of the necessary concurrence of the signalmen at each end of the block, a step further than is done in the systems in general use. The instrument also affords a continuous indication of the signal last transmitted, but this indication does not appear at the transmitting end until the signal has been acknowledged from the distant station. Further particulars of this system may, we understand, be obtained from Messrs. Siemens Bros. and Co., of Queen Anne's-gate.

THE THEORY OF THE TELEPHONE.—M. Cornu has presented to the French Academy a memoir by M. E. Mercadier, on the theory of the telephone. M. Mercadier maintains that the transmission of articulate speech is chiefly, if not solely, the result of molecular motion in the plate of the receiver. Vibrations of the plate as a whole are only capable of yielding a single tone and its harmonics; this tone remains unaltered when the plate is supported at various points which are nodal points for this particular note, but under these circumstances the transmission of other tones is much enfeebled. Such an instrument M. Mercadier calls a mono-telephone. On the other hand, a diaphragm supported in such a manner as to be incapable of performing transversal vibration is still able to transmit speech with perfect clearness, although with considerable diminution of intensity.

ELECTRIC TRANSMISSION OF POWER IN PARIS.—At the workshops connected with the Gare de l'Est in Paris, the engine room situated at one end of the range of buildings, and the repairing shops, situated some distance away, have hitherto been supplied with power by means of belt gearing running underground. This arrangement was not only very wasteful of power but also gave rise to very unpleasant noise and vibration. Five months ago the company put in a dynamo machine and three small motors, and the result of the experiment has been so satisfactory that the whole of the power is now to be transmitted by this means. For this purpose four more motors will be required. The regulation

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of the motors has hitherto been effected by means of a variable resistance connected with each motor. The method of running, whether in series or parallel, is not mentioned.

TUNING AN ORGAN BY TELEPHONE.—A Birmingham paper says that a novel experiment was tried there last week with the telephone. A letter was received by Messrs. Rogers and Priestly, musical caterers in that town, asking them to send an organ to suit a pianoforte to a room at Moseley, where a concert was to take place that night. The firm were totally at a loss to know the precise tone of the piano, and consequently despaired of being able to comply with the demand in time. However, much to their surprise they found that they could communicate with the people at Moseley through the telephone. Forthwith Messrs. Rogers asked that one of the notes of the piano should be struck. When this was done the sound could be distinctly heard in Colmore-row, and by gradually reducing the pitch pipe the tones of both instruments were made to correspond.

ELBERFELD.—The municipal authorities at Elberfeld have decided to undertake the supply of electric light to the inhabitants from the 1st of October next. The charge to subscribers is to be at the rate of three-half pence an hour for arc lamps of 180 candle-power and a halfpenny an hour for incandescent lamps of 16 candle-power, with the condition that the latter are to be used for at least an hour and a half daily, otherwise the charge will be slightly higher. Connections with the main cable are to be made at the subscribers' expense, and the current meters will be supplied by the municipal authorities, the subscribers paying a rent for them, as is usual in the case of gas meters. The average cost of installation in the houses, including connection with the main cable, is estimated at about sixteen shillings for each incandescent lamp; but of course this will necessarily vary according to circumstances in individual cases.

THE LIGHTING OF THE MANCHESTER EXHIBITION.—We have received for publication a long printed description of the electric lighting of the Manchester Exhibition. Several months since our columns contained a tolerably complete account of the scheme, which had been drawn up for the purpose, but, following our invariable practice in matters of this sort, we must defer our judgment on the actual carrying out of the details until we have made our own arrangements for an impartial report. In saying this we do not wish to cast the least doubt upon the accuracy of the description sent out by our Manchester friends, neither do we hesitate to believe that the encomiums lavished upon the contractors are well merited; but we consider that, if an affair possesses any technical importance, the report of a technical journal should be somewhat different in style, and possibly somewhat more critical, than that supplied to the local journals.

THE WAY ELECTRIC LIGHT BUSINESS IS LOST.—According to a local journal the manager of the Southport Gasworks recently obtained tenders for a proposed installation of the electric light for one of the streets in that town. Arc lights of 2,000 candle-power were to be employed, and the space to be lit is 1,400 yards in length and 30 in width, the lighting to extend over 1,800 hours per annum. In response 15 tenders were received, the number of lamps required being variously estimated at from six to fifty, and the cost of installation from £695 to £3,625; the maintenance of installation per annum from £72 to £663, the total estimated cost per annum thus ranging from £194 to £1,098. The natural result of this discreditable episode is that the scheme is to be abandoned altogether. Such tendering as this savours of total ignorance, showing clearly that the conditions required for successful lighting are not understood, or, it may be, are entirely ignored for the sole purpose of getting work at any price.

WATERFORD.—We recently gave some details as to the proposed electric lighting of Waterford. The Town Council came eventually to the decidedly feeble resolution to devote the sum of £60 to the purpose of "experiment." We have not yet received any authentic information as to what has actually been done with the money, but in the *Gas Engineer* we find the following paragraph referring to the matter, which we reproduce verbatim:—"The electric light has been tried in Waterford on the Quay, and in several other prominent positions. The gas was generated by dynamo electric machines, driven by the engines of Messrs. White Brothers. Generally the lights were steady, their brightness being dimmed by the muffed globes. The experiment did not justify the conclusion that the system is adapted to street lighting generally, and this was particularly noticeable in Arundel-square. The lights would have been more fairly tested if displayed in some of the narrower and irregularly built thoroughfares." We can quite believe that the system of generating gas by dynamo-electric machines is not particularly well adapted to street lighting.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The sixty-sixth number of the *Journal* of the above society was issued last week, and contains Mr. Desmond G. FitzGerald's paper "On Reversible Lead Batteries, and their Use for Electric Lighting;" also the paper of Mr. A. E. Kennelly on "The Resistance of Faults in Submarine Cables," together with the discussion which followed. Subscriptions to the amount (up to date) of £121. 18s. on behalf of the Telegraph Jubilee Fund, are acknowledged. It will be remembered that this fund is to be devoted to the enlargement of the society's library.—The important paper by Profs. Ayrton and Perry, on "Modes of Measuring the Coefficients of Self and Mutual Induction," read at the meeting of the society on the 28th ult., is unavoidably held over until our next issue. The next meeting of the society will be held at 25, Great George-street, S.W., on Thursday, May 12th, at 8 p.m., when the discussion on Profs. Ayrton and Perry's paper on "Measuring the Coefficients of Self and Mutual Induction" will be resumed, and a paper on "Driving a Dynamo with a Very Short Belt" will be read by the same authors.

THE FINANCIAL RESULTS OF THE MILAN CENTRAL LIGHTING STATION.—The Milan Electric Lighting Company has declared a dividend of 2·8 per cent. on its capital of £120,000, and carried forward £212. The number of lamps at present in use is 9,688 incandescents and 149 arcs; of this number 2,525 incandescents and 90 arcs were added during the year 1886. The lamps are run in part directly from machines of the old Edison type (of which the efficiency is somewhat low), and in part by means of transformers. The receipts for the twelve months amounted to £25,893, and the working expenses to £18,205. So far the results look remarkably encouraging, but, unfortunately, it is necessary to add that out of the total income of the company £9,333 was received on account of "isolated installations, sale of apparatus, and sundries." If, as seems probable, these items have added little or nothing to the working expenses, it would appear that the £16,500 received on account of central station lighting has barely covered the cost of working. We shall be glad to be corrected in this particular if our impression is wrong. The charge per lamp-hour of 16 candles per annum is 8 centimes (say ¾d). And each lamp (not including arcs) brings in 32s. yearly. It follows that the lamps burn on an average only 512 hours per annum.

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A NEW BATTERY SOLUTION.—The usual method of preparing bichromate battery solutions consists in dissolving bichromate of potash in sulphuric acid and water. This solution, however, possesses the disadvantage of leading to the formation of chrome alum, which, besides increasing the internal resistance of the battery, disintegrates the elements and thus reduces the efficiency of the battery. The *Electrical World* states that in order to remove this difficulty Mr. Wm. R. Kookogey has recently devised a method of removing the base of the chromic salt in the form of crystals, leaving the chromium in the solution. This is accomplished by adding boiling water to a certain proportion of bichromate of potash or bichromate of lime, and while the mixture is still at or near the boiling point adding sulphuric acid. The exact proportions are as follows :—To eight ounces of bichromate of potash or nine ounces of bichromate of lime, two and a-half pounds of boiling water are added. To this is added three and a-half pounds (avoirdupois) of sulphuric acid of a specific gravity of 1·835. The solution so made is allowed to cool and to remain standing for about 24 hours at a temperature of from 60° to 68° Fahrenheit. The liquid is then siphoned off, and is ready for use; and the base or sulphate of the base will be found deposited on the bottom of the vessel.

MULTIPOLAR CONTINUOUS CURRENT DYNAMO.—Messrs. Ganz and Co., of Buda-Pesth, have recently completed a new type of continuous current dynamo. The following description is given by *Industries* :—"This machine is designed for a current of 35 amperes, and a pressure of 1,500 volts, its speed being 1,000 revolutions per minute, and the total weight 14cwt. There are six field-magnets, arranged radially, and fixed to one of the standards; whilst the armature, the core of which is attached on the opposite side to the spindle, revolves round this star-shaped field. The armature is of the usual Gramme pattern, and is wound with 336 coils, each containing twelve turns of insulated wire. A peculiar feature of this machine is the very large commutator, containing not less than 336 sections. Equipotential coils are cross coupled, after the manner of the Victoria and Gülcher machines, so that the current entering by one of the brushes is split into six circuits, each carrying nearly six amperes, and leaves the armature at the other brush, the angular distance between the brushes being 60 degrees. The total resistance of the armature is ·97 ohm, and that of the magnets ·28 ohm. The makers claim for this machine a very large electrical efficiency, but state that the design is rather expensive. This type of dynamo is intended for the transmission of energy."

EARLY TRANSFORMER PATENTS.—The following extract from a patent of Deprez and Carpentier, dated September 24th, 1881, No. 4128, will be interesting to many of our readers :—"Another mode of conveying an electrical current to a distance with as little loss of power as possible is based on the following discovery: When a quantity current proceeding, for instance, from one or more elements of a Bunsen battery, is passed through the large wire of a Ruhmkorff coil, high-tension currents are produced in the small wire which can overcome a large resistance, and can consequently be conveyed to a considerable distance without appreciable loss of power. If this high-tension current be then made to pass through the small wire of a second coil at the receiving station, it will induce a quantity current that will have nearly the same force as the quantity current acting on the first coil, and which can then be employed as a motive power, or for other purposes." One of the claims in the patent is as follows :—"The method of conveying a quantity current to a distance with minimum loss, by first converting it into a high-tension current by means of an induction coil, which current, after being *conveyed to the distant station, is there reconverted into a quantity current by a second induction coil.*" This would appear to be a distinct anticipation of the Gaulard-Gibbs patent, so far as the principle is concerned.

ELECTRIC ALARMS FOR MORTUARY CHAPELS.—The mortuary chapel of the Madrid Municipal Cemetery has been supplied with an electric apparatus communicating with the residences of the cemetery officials, with the object of preventing the possibility of a person being accidentally buried alive. The apparatus consists of a double vertical metallic cylinder, on the top of which a copper disc is delicately poised, in such a way that the least movement of the coffin on which the apparatus is placed would cause the disc to fall into the cylinder, and send a current through the circuit of an electric bell. The experimental trials seem to have been perfectly successful, and the use of Signor Estelat's apparatus would render impossible such a horrible occurrence as was described a few days ago by the Odessa correspondent of the *Daily News*, who states that Major Maguroff, an aide-de-camp to the Governor-General of Odessa, died, as was supposed, a few weeks ago, and was interred forty hours afterwards. Nearly three weeks afterwards a workman who was executing some repairs in the family vault thought he heard a noise in the coffin, and that the lid was partly forced open. The coffin was at once opened, when the body was found face downwards, the face being dreadfully lacerated, and the flesh gnawed from the hands. The officer was dead when the coffin was opened, but the body was still bleeding, showing that death had only just taken place. It is impossible to avoid the reflection that such fearful and revolting episodes may be more common than is generally supposed, seeing the extreme improbability under the present system of interment of the truth coming to light.

ELECTROPLATING FLOWERS AND INSECTS.—A new process for electroplating delicate organic bodies, such as flowers or insects, which is carried out upon a large scale by a French company, is described as follows :—"The process consists in the employment of an albuminous liquid, with which the different substances in question are treated to prepare them for metallisation. This liquid may be thus obtained: A quantity of snails or slugs are first washed in ordinary water to free them from all earthy or calcareous matter. They are then placed in a vessel containing distilled water, and are left here sufficient time to give off slowly their albuminous matter. The albumen thus obtained is now filtered, and boiled for about an hour. After the boiling is added a quantity of distilled water sufficient to replace that lost by the boiling, and about 3 per cent. of nitrate of silver. This liquid is then placed in bottles, hermetically closed, aud kept in the dark. It will thus keep without any alteration. To use this liquid for the preparation of the objects, about 30 grammes of it is dissolved in about 100 grammes of distilled water. In this solution the objects are submerged for a few moments; they are then placed in a bath consisting of distilled water with about 20 per cent. of nitrate of silver in solution, and afterwards submitted to the action of sulphuretted hydrogen gas, to reduce the nitrate of silver adhering to the albumen-covered surface of the object. Thus treated, all organic matter is rendered fit to receive a galvanic deposit; and the galvanic products obtained by this process are far superior in fineness and neatness to those obtained by any other known process. Even the finest and minute fibres and veins, the smallest unevenness of surfaces, and hairs scarcely visible to the naked eye are clearly discernible, and come out with striking neatness, the

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metallic deposit being of perfectly uniform thickness and adherence."

Constant Current in the Series System.—We are informed by Mr. Bernstein that in one of his latest installations he has made use of a very simple method for obtaining a constant current in a system in which a varying number of glow lamps is placed in series. For this purpose the ordinary series dynamo is used, driven independently by a small steam engine. There is no regulator of any kind in action under normal circumstances, and the centrifugal regulator of the steam engine only comes into play in case an accident should occur, and the engine be liable to run away. Under these circumstances the engine will adjust its speed according to the number of lamps which are in the circuit, and an approximate constant current is produced. The reason is very simple, and has been given by others already. The strain on the belt of the dynamo merely depends on the strength of the current in the armature, if the field is constant. This strain is balanced by the average pressure of the steam in the cylinder. If, now, the number of the lamps is decreased, the current in the armature and in the field-magnets tends to increase, and consequently the strain on the belt is altered in the same way; but if the average pressure of the steam is not altered the speed of the engine must decrease until an equilibrium is established again. The reverse takes place if the number of the lamps is increased. In the installation in which this method is at present in use the maximum number of lamps is 30, and the current 9·5 amperes; if this number was reduced to one-half the current rose to 11·25 amperes. As the number of lamps in this special case is never much altered, the method was considered sufficiently satisfactory. The results would have been better if the steam pipe leading from the boiler to the engine had been shorter and of larger cross section, so as to obtain a uniform average pressure in the cylinder irrespective of the speed of the engine.

Overhead v. Underground Wires.—Under the auspices of the United Wards' Club, at the Salutation Tavern, Newgate-street, on the 20th ult., Mr. Donald Nicoll, M.I.C.E., delivered an address on the above subject. Mr. G. T. Thornes presided. Mr. Nicoll mentioned that over twenty years ago he had successfully laid about ten miles of underground conductors by a method he had since patented. He proceeded in a humourous manner to describe the dangers and inconvenience of overhead wires, and asserted that these might be economically and practically avoided by the employment of his system of embedding wires in a composition of which bitumen is the chief ingredient. He summarised the requirements of subterranean telegraphy as follows: Lasting insulation, *i.e.*, security against gas, water, or changes of temperature; security against accidents and easy separation; power of easily attaching branch lines; capability of passing round, over, or under obstruction; freedom from injury by friction during examination or repair; and cost not to exceed overhead work. After showing that while our own Government refused to adopt his system, France and Germany had adopted it for military purposes, and the Government of New York decreed that no other than a bituminous underground system should exist within its territory, Mr. Nicoll adverted to the use of bitumen as a substance indestructible by ordinary climatic or telluric action, as shown by Holy Writ, and the ancient use made of it for embalming among the Egyptians. It really does not reflect credit, he contended, on the country of the telephone that, while already the United States have 325,574 telephones in work, Great Britain and Ireland own but 13,000. Nothing, he proceeded, would cheapen our food system more than a good and cheap telephonic system, penetrating into villages, and much valuable time would thereby be saved. Assuming the object of the City of London to be the possession of the most effective and commercially remunerative sources of supply of telephonic as associated with telegraphic communication, he proposed and showed courses of treatment; one for main arteries like Cannon-street, Oxford-street, and the Strand; one for less important thoroughfares, and a third for railway sides and suburban and rural roads. The lecturer then went into details of his own scheme, showing the various precautions he had taken to procure the essentials of an underground system enumerated above. Mr. C. H. Belcher moved a resolution to the effect that the subject is well worth the consideration of all local authorities, with a view to petitioning Parliament for the adoption of carrying all wires underground. Mr. J. Hudson seconded, and the resolution was carried unanimously. The services of the lecturer and chairman were then suitably acknowledged.—*The Citizen.*

The Westminster Aquarium Lighting.—There has been recently a large extension of electric lighting at the Westminster Aquarium. The installation now consists of a 30 horse-power nominal Robey compound fixed engine, 30 arc lamps of 2,000 candle-power (taking 8 amperes and 45 volts each), 10 arcs of 3,000 candle-power (taking 16 amperes and 45 volts each), about 200 incandescent of 16 candle-power, and 40 of 10 candle-power; two Gülcher No. 4 low-tension dynamos, each capable of generating about 20,000 watts. The engine is furnished with two 7ft. fly-wheels, which run at 118 revolutions per minute, the boiler pressure being 120lb. per square inch. The engine is supplied with one of Richardson's patent governors, which does its work well. The dynamos, which give 65 volts 320 amperes and 65 volts 425 amperes respectively, are run at 490 and 570 revolutions per minute; each is driven from a fly-wheel of the engine by an 8in. Gandy belt, travelling at 2,560ft. per minute. On the switch-board there is a large exchange switch, by which one dynamo can be switched on to the most important circuits, should the other break down; there are two main switches, carrying about 200 amperes and four 80-ampere switches, so that there are six circuits in all leaving the dynamo room. Two main cables, which run the whole length on opposite sides of the building, one of 19 strands of No. 10 B.W.G., which tapers to 7/15, and another of 37/15, are carried up in the roof on specially-made insulators. From the 19/10 cable on the stage-side of the building there are taken circuits to eight arc lamps of 3,000 candle-power, seven of which are placed in a straight line down the centre of the building, and one on the stage, and about 60 incandescents, 40 of which are used for stage effects, together with a 500 candle-power hand arc lamp, a device of Mr. Mountain, the manager of the company, and which takes the form of a pair of sugar tongs, and for the short time it is required does its duty remarkably well; the other incandescents are used for lighting some working models, &c. The 37/15 cable on the opposite side supplies nine 2,000 candle-power arc lamps, six being under the galleries and three in the Imperial Theatre. The same cable supplies 161 incandescents, of which 51 are in the Imperial Theatre, 40 light the fish tanks, 45 the dining rooms and bars of Messrs. Bertram and Roberts, the next being used for the lighting of stalls and billiard rooms. In the Imperial Theatre all the switches are placed behind the scenes, so that the stage manager has control of the lights during the performance. The rest of the circuits supply seven arc lamps of 2,000 candle-power outside the building, six in the upper galleries and roof, and six in St. Stephen's Hall. The time of lighting is from half an hour before sunset until 11:30 p.m. The installation is under the charge of Mr. A. J. Baron, of the Gülcher Electric Light Company.

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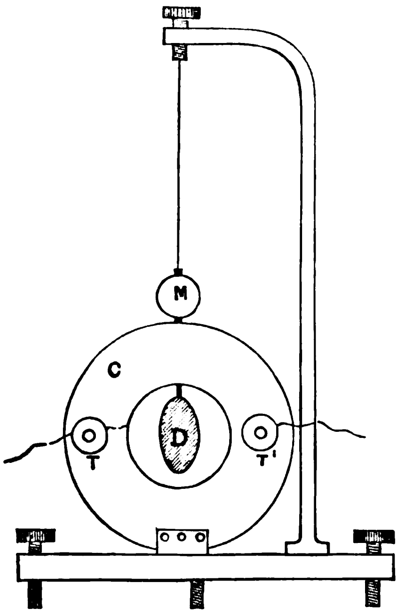
A COPPER DISC GALVANOMETER FOR ALTERNATE CURRENTS.

BY J. A. FLEMING, M.A., D.SC.

Nearly a year ago some theoretical investigations on alternate currents led me to the conclusion that a conducting non-magnetic body, suspended in the field of a coil traversed by alternate currents, would be acted upon by forces in certain positions due to the reaction of the variable currents in the coil and the currents induced in the conductor. Until a few months ago the experiment was not, however, tried. On March 12th, 1887, at a meeting of the Physical Society, was exhibited an apparatus, which I have since rendered more delicate, for making evident this phenomenon. On a wooden bobbin similar to a galvanometer bobbin is wound a coil of 200—300 ohms of carefully insulated No. 36 wire. The wire should be preferably double silk covered, well baked and paraffined before winding, and the whole bobbin boiled in paraffin after winding. Two coils of this description may be mounted on a base board like galvanometer coils. In the aperture of the coils is suspended a light disc of copper foil, so hung by a glass fibre or silk bifilar suspension that its normal position is one with its plane at an angle of 45 deg. to the axis of the coil. This disc may be cemented to a very light glass fibre or aluminum wire, carrying at its upper end a mirror, M.

Fig. 1.



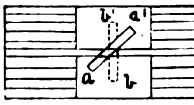


Fig. 2.

The whole arrangement should be protected from draughts by a glass shade. If a continuous electric current is sent through the galvanometer coils there is no motion nor change of position of the copper disc, but if a rapidly interrupted current is sent through the coils, or an alternate current from a small induction coil is allowed to traverse the coils, then there is an immediate deflection of the copper disc, which tends to take up a position with its plane more nearly in the direction of the axis of the coil. In the first figure the apparatus is shown in elevation, and in the second figure in plan. The normal position of the copper disc is *a a'*, and the position it endeavours to take up under the action of the alternate current is shown by the dotted lines *b b'*. The instrument accordingly forms a galvanometer for alternate currents; but which, unlike the electro-dynamometer, is not affected by continuous currents.

The rough general theory of the action is to be sought for in the fact that the copper disc possesses a very sensible time constant, and hence there is a lag or delay in the rise to a maximum of the currents induced in the disc by those in the coil. Consider, first, the simplest case. Let a current be first started in the coils and then maintained constant. The rise of the current in the coils generates by induction an oppositely directed current round the periphery of the copper disc. This induced current in the disc lasts during the whole time that the current in the coils is rising to a maximum During the rise and decay of the induced current in the disc it is virtually a magnetic shell, and one face of the disc is north-polar and the other south-polar. The well-known laws of electro-magnetism indicate that the disc must endeavour to turn itself, so that the direction of the currents in the disc is similar to the direction of the current in the coil. Hence it does this as far as it can by making a small displacement in such direction as to place its plane more nearly in the line of the axis of the coil. If the disc had no sensible self-induction and no finite time-constant, the stoppage of the current in the coils would be immediately followed by a like-directed induced current in the disc. The forces on the disc are in this case opposite to those acting on it at the starting of the current, and as the quantities of the induced currents are equal, if the disc possessed no self-induction, the rapid break and make of a current in the coils would exercise no effect in disturbing the position of the copper disc. As a matter of fact the disc does possess self-induction, and the operation of this is to delay the time when the currents in the disc reach their maximum. When the current in the coil is started and stopped with regular frequency, it is easily seen that in consequence of this self-induction of the disc the time of maximum reverse induced current in the disc will happen when the inducing current has arrived at a larger value on its way up to *its* maximum, whilst the time of maximum direct induced current in the disc will happen when the inducing current has more nearly fallen to zero again. Accordingly the disc experiences alternate impulses, which are opposite but not equal, and is then pushed into a fresh position in the field in which the force of torsion of the suspension is equated to the difference between these forces, and it takes a steady deflection under this intermittent current in the coil. If, instead of supplying the coil with an intermittent current, it is fed with an alternate current from a small magneto machine or induction coil, the effect is increased because the change of strength of magnetic field, and, therefore, the forces brought into play are greater. The explanation of the behaviour of the disc is, however, the same. The experiment illustrates very well the fact that such a disc possesses a very sensible time constant, and that there is a lag or delay in the rise to a maximum of the current induced in the disc.

If in place of a copper disc a soft iron disc is employed, the effects become complicated by the tendency of the disc of iron to set its plane along the lines of force of the field, but the instrument becomes at the same time more sensitive to induced currents, and can be made to render galvanometrically visible the currents in a Bell telephone when it is spoken to. I am intending to investigate more completely the behaviour of discs of various metals and forms, with the object, if possible, of obtaining more information as to the best form to give the instrument in order to render it useful for the detection or measurement of very feeble alternate currents. It is evident that an instrument which will take the place of the telephone as a detector of alternate currents, yet appeal to the eye instead of the ear, would be a useful acquisition in the laboratory. It would form an interesting investigation to determine the exact forces on the disc in determined cases; but the above outline of a theory will perhaps render intelligible the action of the instruments.

Lighting Caves in Styria.—At a village in Styria there are some remarkable caves containing stalactites of great beauty. Herr Kraus, upon whose property these caves are situated, has placed a turbine in a neighbouring stream, and utilises the power to light the caves with 15 arcs. The effect produced is said to be wonderfully fine.

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THE TREATMENT OF THOSE SUFFERING FROM THE EFFECTS OF HIGH-TENSION ELECTRICITY.

M. Brown-Séquard, the eminent physiologist, made a brief communication on the above subject to the French Academy, which deserves to be carefully noted by all electricians who deal with dynamo machinery. M. Brown-Séquard, referring to a recent communication of M. d'Arsonval upon the same subject*, strongly endorsed the advice that in all cases of apparent death from electric action, artificial respiration should be immediately resorted to. For some time past there has been in use at the College de France, a mode of exciting the respirative organs in cases of arrest by inhibition, which is more easily applied and far more effectual than the methods previously employed. This process consists in the application of what the medical electricians call "faradisation"—that is, excitement with a small induction coil—the electrodes being applied externally *on either side of the larynx.* The skin of the neck should either be moistened or a superficial incision should be made in order to overcome the insulating power of the epidermis. By this means the nerves which govern the respirative organs are directly stimulated, and, if life still exists, will speedily resume their normal functions.

* See last week's *Electrician*, page 53?.

CORRESPONDENCE.

THEORY OF SECONDARY CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I will take the letters in order. First, as to my assertion that Mr. FitzGerald mixes his notations. He uses modern symbols and old calorific equivalents. In old days, when water was HO, it was correct to say that, say, Andrews's value for Zn, O is 42,408, but now that water is H_2O Andrews's value is 84,816. H_2O is a symbol which means one molecule of water, or 18 mass units of water. $H_2, O = 67,616$ means that 2 mass units of hydrogen combining with 16 mass units of oxygen raise 67,616 mass units of water 1° C. The unit of mass is now the gram, and H_2O stands for 18 grams of water. This is the meaning now attached to symbols by chemists, wisely or unwisely, and if a writer uses H_2O to denote 9 grams of water he lays himself open to be misunderstood, as he is using the symbols incorrectly. It is in using symbols in the old way that I mean that Mr. FitzGerald is seventeen years behind the age. I believe this date is inaccurate, but I do not know when the new notation came in. Mr. FitzGerald seems to think he is following the usual practice in writing Zn, O = 24,408. There is no reference library in Chelmsford, so, finding the question as to notation growing more serious, I went to Booksellers-row and got a second hand "Miller's Chemical Physics." I have not enough books to take a census, but I find as follows:—Miller gives tables, and gives, for instance, 42,408 as the "calorific equivalent" for 8 grams of oxygen. This is, of course, quite intelligible. Miller does not, I think, write Zn, O = 42,408. Watts, Vol. III., p. 105, takes one atom of zinc oxide, thus getting 86,450. He takes also one atom of water, thus getting 33,881 for formation of water. In fact, there is no system in these works. Thomsen and Naumann use the new notation, in which H_2O stands for 18 grams of water. Berthelot uses the old notation, and writes water H O. Pattison Muir and Muir Wilson, whose "Elements of Thermal Chemistry" is certainly the standard work in this country, use the new notation, as Thomsen and Naumann do. Mr. FitzGerald is quite consistent in his use of formulæ, but he is consistently confusing two systems of notation. I do not say he is tripping or blundering; if there is any mistake it is in forgetting that a symbol stands for a certain number of mass units.

I look upon this as a mere question of notation, which, when one understands that he uses symbols in an eccentric way consistently throughout, makes little difference, and the question of notation is that on which I have least difficulty in following Mr. FitzGerald.

I do not differ from Mr. FitzGerald in his estimate of Dulong, Andrews, and Favre and Silbermann, but their values are just as good when expressed in modern notations. In all cases, without depreciating their work, I should prefer Thomsen's or Berthelot's results as being more likely to be accurate.

I do not really say that Pb combining with O and SO_3 simultaneously or consecutively would give 156,110, but that Pb combining with SO_4 would. It is confusions like this that make it difficult for me to understand Mr. FitzGerald. Pb, O, SO_3 is one thing, Pb, SO_4 another. Pb, O is 50,310 (Thomsen) and PbO, SO_3 is 62,670, so Pb, O, SO_3 is 112,970, not 156,110. Similarly Zn, O, SO_3 Aq 106,090. This last figure is given direct by Thomsen. Why the zinc is less than the lead is probably because lead sulphate is solid. But Mr. FitzGerald gives 106,838 as the heat of Zn, SO_4; how does he get this? I should expect Zn, SO_4 to be greater than Pb, SO_4; but that is not really to the point. I hold that the heat of combination is not a measure of electromotive force, and not a measure of chemical affinity. Mr. FitzGerald, on the other hand, apparently assumes both of these as axiomatic; but, as far as I understand him, considers one action at one plate only.

If a cell is made of zinc and brass, any sulphate of zinc formed by consumption of the brass would be due to local action, and would have nothing to do with the other plate. The analogy does not hold. Of course, polarisation would complicate matters; but, no doubt, Mr. FitzGerald does not wish to complicate matters by considering that. Apart from polarisation, the brass might be considered two plates, one of zinc and one of copper. There are therefore two zincs and one copper, and the copper is metallically connected to one zinc. Any sulphate of zinc formed would have nothing to do with the E.M.F. of the copper and another zinc plate. An alloy may not behave exactly as two separate metals, but that does not make the analogy any better.

Passing to Mr. Williams, I do not see why the Pb, SO_4 cannot be credited because the Pb is not supplied by the electrolyte. The point is that it is formed on discharge. As in most cells such salts are decomposed on that plate on discharge, it no doubt strikes Mr. FitzGerald and Mr. Williams as strange that it should be credited. In most cases such salts as Z_nSO_4 are formed by oxidation; in this case Pb SO_4 is formed by reduction. I must accuse Mr. Williams of hypotheses. What is an electrolytic thread? It must not be forgotten that in the calculation Pb, O_2 was debited. The point is that the lead is reduced, though if you take Pb, SO_4 alone without taking into account the other reactions, it might appear that I was crediting results of oxidation on both plates. If there were such a salt as lead persulphate I might have debited Pb SO_4, SO_4 directly, or I might have debited Pb $(SO_4)_2$, and credited Pb, SO_4, the results would have been the same; but in the latter case crediting the Pb, SO_4 looks anomalous till it is remembered that Pb $(SO_4)_2$ was debited. If, instead of writing Pb, O_2 debited and Pb, SO_4 credited, I had debited PbO, O first and then exchanged the PbO for Pb SO_4, probably neither Mr. FitzGerald nor Mr. Williams would have objected, though the sum would really have been the same.

Again, suppose for the moment no sulphate formed, and that the peroxide is simply reduced to monoxide, I might simply debit PbO, O, or I might debit Pb, O_2 and credit Pb, O. The result would be exactly the same, though the Pb, O appears on the credit side. But as Pb SO_4 is formed, that is credited instead of the Pb, O.

As to balancing accounts, I should be very glad if Mr. Williams could make the heats fit the volts; but I should be surprised, for I hold that the E.M.F. of a cell cannot be measured by the heats of combination, and that the heats of combination are not measures of chemical affinity. Perhaps the E.M.F. is the measure of the chemical affinities, but I do not say it is.

Mr. Phillips raises a question, and a very large one, but it is really outside the present discussion. Mr. Phillips prefers the old notation, because he considers it fits electrical phenomena better; he may have other reasons, but I have not read his book. Whether I prefer the old or new notation myself is not

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to the point; the new is in general use, so I must use it. I do not—at least, with my present knowledge of such subjects—regard "It is me" or "The best of two" as bad English; but the influence of Latin grammer pedantry has so ruled it, and it is therefore advisable to say, "It is I," and "The better of two." But Mr. FitzGerald does not use the old notation; he uses a mixture.

Mr. Phillips thinks the "absurdities of our modern notation" have misled me and "my friends," by which title he honours the whole scientific world, some French chemists being excluded—probably as enemies. I can assure him that no confusion arises from the new notation. The question of how many calories go to a volt is not one of fact, but of notation; and electro-chemists divide by two when discussing bivalent radicles without getting hopelessly fogged by such abstruse mathematics. If Mr. FitzGerald says H_2, O = 34,000, we know he really means that 9 grams of oxygen and hydrogen raise 34,000 grams of water 1 degree, but would rather he kept entirely to the old notation and said H, O = 34,000. If Prof. Thompson, on the other hand, says H_2, O = 68,000, we know he means that 18 grams of H_2O give 68,000, which is the same assertion put differently.

I do not know what work of Lord Rayleigh's Mr. Phillips refers to, but from his account I have no doubt Lord Rayleigh was determining by electro-deposition the ratio of the quantities of silver and copper deposited by a coulomb, so that electricians might use copper voltameters for calibrating work. He has also very carefully determined the weight of silver deposited by a coulomb. If the combining weights, determined by chemical means, were absolutely accurate there would be no need to do this, but as these data are sometimes incorrect it was advisable to determine the ratio by the method of electrolysis. Lord Rayleigh wished, in fact, to check the ratio of the combining weight of copper as given by chemists, and did so, but Mr. Phillips imagines that the whole of Lord Rayleigh's "learned experimentation" is some frightful mental struggle against the difficulties introduced by the new notation and the necessity of dividing by two, and shows how the whole could be simplified by assuming the data as right to begin with.

I do not know the research by Sabine mentioned by Mr. Phillips.

When Prof. Thompson says 1 volt = 46,000 calories, he, of course, means when the radicles are bivalent. As to Mr. Armstrong's 40,000, I expect it is a misprint. As to the last statement, that a volt is half the alleged value, I can only repeat that there is no question of fact open. If Mr. Phillips writes H_2O = 18 = 68,000 calories, which is according to the new notation, he must divide by 46,000, not 23,000, to get the volts. If he writes HO = 34,000 he is using the old notation, and must divide by 23,000.—Yours, &c.,

JAS. SWINBURNE.

ON VARNISHING INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As Mr. Cherrill's article which appeared in your issue of the 8th ult. relative to the above subject appears to have been recopied into many scientific journals, it is evident the subject is considered of some importance by literary men; but, as there are two opinions as to this, permit me to say that I think it is somewhat astounding that electricians should go to an immense amount of trouble and expense in order to colour the bulbs of incandescent lamps for decorative lighting, when lamps of any desired tint and colour can be obtained made of real coloured glass at about 3s. per dozen extra.

Furthermore, any chemical or varnishing process, however good it may be, is bad for this purpose, and detrimental to the life of the lamp, as varnish absorbs and retains moisture, and does not allow for proper expansion of the bulb when heated by an excessive flow of current.

Besides, at its best, the varnishing process can only produce a dirty and unsightly lamp, which greatly obscures the light, and which was apparent to all practical men who witnessed those installed in the grounds of the late Exhibition at South Kensington. It would also be interesting to know how many times the lamps used at the Exhibition were re-dipped, and how many bulbs were broken; also how many men were kept continually employed to carry out this process, to say nothing of the amount of strong language used by the victims who were compelled to bend over the vessels containing the nauseous smelling compounds used for this purpose, which could easily have been avoided by the payment of a small royalty to our firm for permission to use coloured and fancy glass for the bulbs of their lamps, the entire patents of which are the property of our firm, subject to certain licenses granted for use thereof.*

Undoubtedly, for many purposes, coloured globe lamps add a charm to electric lighting. They can be placed amongst plants, flowers, ferns, &c., and what is prettier than to see the shrubs in one's conservatory studded with small 2-volt fairy lamps made in fancy colours, dozens of which can be lighted by the aid of a single storage battery of suitable capacity, and this without damage to the plants.

The subject is of considerable importance to the electrical world, as the demand for coloured and fancy striped lamps is greatly increasing for illuminations; and those electricians who have the good taste to install the real article instead of the sham (although it may cost a few pence more per lamp) will be well repaid by the satisfaction of knowing that their customers will be better pleased by the beautiful effect obtained by the use of real coloured glass over that of a substitute in the shape of varnish or paste.

In conclusion, I will content myself by simply reminding electricians that imitation goods, however well got up, are never in appearance like the genuine article, nor will a varnished incandescent lamp uphold the dignified appearance and beautiful effects to be obtained by using real coloured glass incandescent lamps for fairy illuminations.

If you can find space for the above, please insert same, and oblige.—Yours, &c., ARTHUR SHIPPEY.

13 and 14, King-street, Cheapside, E.C.

[* We should be glad if correspondents would refrain from mixing information in their letters which partakes so closely to the nature of advertisements of their own specialities.—ED. *E.*]

AUTOMATIC ACCUMULATOR SWITCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Being away from home last week I was unable to reply to Mr. Neville's letter commenting upon my accumulator switch in your issue of April 22. As regards the form he suggests, and moreover has had in use some time, I may say that it is one which I had under consideration last September, being suggested to me by Mr. Frank Nalder. My objection to it was two-fold—first, the permanent magnet; and second, the fact that unless an auxiliary switch were used, a small current would be always leaving the battery. Here certainly we have a greater source of waste than is possible in the form Mr. Neville criticises. The chief objection he suggests is the supposed oscillation of the armature. I must remind him that if the armature can only be drawn down at an E.M.F of, say, 130 volts, then, if a reversal takes place, the E.M.F. has considerably fallen; and therefore the shunt coil is unable to again draw down the armature until an increase of speed raises the E.M.F. again to 130.—Yours, &c., J. M. V. MONEY-KENT.

[CORRESPONDENCE *continued on page 565.*]

ELECTRIC TRAMCARS AT BRUSSELS.—A regular service of tramcars, driven by Julien storage batteries, has now commenced at Brussels. Eight cars are at present in use, running on the line from the Place Royal to the Rue de la Loi. The system has worked very well so far. The Brussels public complain, it seems, that the appearance of the cars leaves much to be desired from an æsthetic point of view, and also that they are constructed in such a way as to make it very difficult to get on or off while they are in motion. Probably, however, it is understood that these features are not essential to the electric system.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XVIII.

Volume XVIII. of "The Electrician," Price 10s. 6d., will shortly be ready.

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With this number a Supplement is issued (Gratis), containing the Index to Volume XVIII. This Supplement should be received with every copy of the paper. Complaints of non-receipt should be forwarded to the Publisher.

CONTENTS.

Notes ... 557
A Copper Disc Galvanometer for Alternate Currents. By J. A. Fleming, M.A., D.Sc. Illustrated ... 561
The Treatment of those Suffering from the Effects of High-Tension Electricity ... 562
Correspondence. Illus. 562 and 565
THE UNITED TELEPONE COMPANY AND LONG DISTANCE TELEPHONY ... 564
Indu.tion Coils Graphically Treated. By Gisbert Kapp. (Concluded.) Illustrated ... 568
The Measurement of the Intensity of the Magnetic Field. 571
The American National Electric Light Association ... 571
The Wreck of the "Volta" ... 572
Companies' Meetings—
West Coast of America Telegraph Company ... 573
Great Northern Telegraph Company of Copenhagen ... 573
Brazilian Submarine Telegraph Company ... 574
Submarine Cables Trust ... 574
City Notes, &c. ... 574
Companies' Share List ... 574

THE UNITED TELEPHONE COMPANY AND LONG-DISTANCE TELEPHONY.

It was not without some misgivings that we came to the perusal of some recent articles in certain organs of the financial world relating to the affairs of the UNITED TELEPHONE COMPANY. We have no particular admiration of the way in which that company has discharged its public duties; and, besides finding fault with its engineering work on our own responsibility, we have repeated the complaints of their customers on many occasions concerning the manner in which their telephonic business is done. We are even now disposed to endorse the verdict of one of the organs above referred to, namely, that "London, which is indisputably the finest field for telephony in the world, has so far derived least benefit from the art. London has paid higher rentals, had a less satisfactory service, and been subject to more annoying interruptions than the smallest one-horse provincial town." Another authority says of the UNITED TELEPHONE COMPANY that "they do badly the work which lies under their nose, and the work which lies beyond it they do not pretend to do at all." All this, we are now assured, has become so notorious that steps are about to be taken to transfer the management to more energetic hands; and the *Statist* even gives currency to the "market opinion" that one of the managers of the American telephone companies ought to be fetched over here to teach the UNITED COMPANY how business is done in the States. For our part, we do not want the business to be done in that fashion, and we question whether the shareholders, still less the British public, would like it if they tried it. The faults of the United Company's administration are numerous and serious enough, but they are chiefly those which usually attach to an irresponsible monopoly. The public will gain nothing by a change of hands from one set of irresponsible monopolists to another set. And we are the more certain of this in the particular case under discussion because the critics whom we have been quoting are confessedly speaking not so much in the interests of the public as in those of the "market."

Such, at all events, is the conclusion we arrive at after carefully reading, for example, the utterances of the *Financial News* and the *Statist* on this subject—both evidently inspired with the same idea, if not written by the same hand. We go with them entirely in desiring to improve the telephone system of this great metropolis, and to get its usefulness extended in every practical way. Better instruments, better wires, better service, and better terms are urgently wanted; but we see no prospect of these improvements foreshadowed in the organs of finance just quoted. As to the transfer of this company's property to another "operative company," we will say nothing until we know exactly what it means. But on the other part of the scheme we can speak more positively. It is designed to extend the metropolitan telephone service to the provincial centres, and combine them into something like an administrative whole. No exception need be taken to this idea, provided it has been proved to be practicable; but we fail to see in what respect the local telephonic service would be improved by it. Our one great requirement, according to the *Statist* and the *Financial News*, is long-distance telephony. The Parent Company does not provide this, except in a useless experiment to Brighton, whereas her provincial offspring do provide it. London ought to be in direct telephonic communication with Lancashire, Cheshire, Yorkshire, Northumberland, and various parts of Scotland, where large areas are covered by telephone "trunk lines," which work well, and pay good dividends. Why should not London and its suburbs be united to those remote industrial areas? Probably the directors of the UNITED TELEPHONE COMPANY could give the reason why offhand. But not so the general public, who are easily misled on a technical matter of this kind, especially when its advocates, as ignorant as themselves, support it with unimpeachable figures, and with an enthusiasm which leaves no room to doubt their perfect good faith. We repeat, we have no objection to the scheme as such—on the contrary, we have every reason to wish it success; but, as set forth by these financial journals, we have no hesitation in saying that although the facts supplied to their leader writers may be all correct, the inferences drawn from them are mostly all erroneous.

Had they pointed to recent discoveries relating to long-distance telephony, we might have sympathised to some extent with the financiers. The possibilities of long-distance telephony, we may inform them, have been immensely increased by the newly ascertained electrical capabilities of bare copper wire. But

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copper wire is expensive, and when you talk of connecting London with Lancashire, it means at least nearly 300 miles of it to begin with; and to compare this with the so-called trunk lines of Lancashire is technically absurd, and we should say financially misleading. In reality, the existing metropolitan system resembles pretty closely the "long-distance" lines of the counties we have named. It should be remembered that the wire from Brussels to Paris is a Government wire; and that Governments usually work their wires to the fullest capacity to make them pay; this is done in the case in question, the wire being switched on to the general post offices after Bourse hours. Here, then, is an error at the very outset—the error, namely, of confusing comparatively inexpensive schemes with exceedingly expensive ones. When we turn to the question of profit a similar error is apparent. "On the face of it," says the *Financial News*, "there is a boundless revenue in long-distance telephony." We were glad to learn this; but on examining the writer's arguments we speedily unlearnt it. We are told that a long trunk wire "hired out for three or five minutes at a time all through the day will, at a very small rate per hour, bring in more than even the highest exchange subscriptions." This is good news; but how does he make it out? The United Company charge £20 per annum, which is little more than 1s. per diem. At 3d. each it would require only four telephonic conversations per diem to earn as much, and the writer justly observes it would be a poor wire that did not have more than four customers in the day. On the Paris-Brussels trunk line, we are told, they often get as many as 20 conversations in the hour; but, taking the average at ten per hour in a working day of twelve hours, the writer arrives at the curious though quite accurate conclusion that this "would make a trunk line capable of earning thirty shillings per day!" Evidently the writer thinks that because it pays to erect a wire, one of many hundreds, say, from Coleman-street to Capel-court, earning little more than a shilling a day, it would pay thirty times better to erect a solitary wire from Capel-court to Liverpool. The exact converse of this extraordinary proposition would be far nearer the truth. If no better financial argument than this can be found for the construction of long-distance telephone wires the public had better have nothing to do with them.

The writers we have been quoting are equally at fault when comparing or contrasting the relative capacities of telegraphy and telephony. Much is said about the delays and errors of telegraphy. Every telegram takes half an hour or longer to deliver, and it is always inaccurate; whereas in telephonic conversations the correspondents are apparently glued to their posts, and always ready for a threepenny "turn." At the Paris Bourse Frenchmen are described as standing *en queue* at the telephone boxes at the rate of twenty-three per hour; presumably twenty-three Belgians are standing at the Brussels Bourse in exact correspondence. No delay! and, of course, the speaking is perfect. But taking the twenty-three customers per hour as a reality, how does that compare with the telegraph? Would it surprise the *Statist*—which is responsible for this fancy picture—that nearly ten times that number of customers can be disposed of by telegraph in the same space of time. Between the offices of London and Liverpool over 200 messages can be got through on a single wire within the hour; and it is quite a common thing at the Stock Exchange to receive a written telegraphic reply in less than five minutes. No doubt there is room for the telephone as well, for special purposes on such wires, and customers would be found for them. But then, unhappily, these wires do not belong to the telephone companies; and to say that any wire exclusively telephonic over a long distance would pay on such terms as those indicated above seems to us to be contradicted in the fact that on the Paris-Brussels wire the charge for five minutes' conversation is, not 3d., but half-a-crown.

CONCERNING THE HISTORY OF SECONDARY GENERATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As the attention which has lately been paid to the distribution of electric energy by means of secondary generators has had the effect of evoking much discussion regarding priority of invention, I beg permission to make the following remark:—

It is argued that Mr. Jablochkoff has to be considered the first inventor of the system in question by reason of his patent No. 1,996, 1877, and it may therefore be worth while to look into the contents of this specification. Mr. Jablochkoff's invention consists broadly in the use of a lamp in which a piece of kaolin is held between two metal clamps, and a spark is supposed to travel along this kaolin and render it luminous. In order to get the tension necessary for such a spark, he intends to use an induction coil in the ordinary manner, so as to obtain in the secondary wire the high tension required. The use of alternating currents is proposed, and it is mentioned that several of these induction coils may be placed in series.

This certainly does not mean the conversion of high-tension currents in the main into low-tension currents for the lamps, which is a fundamental point of the present system of distributing electric energy by means of secondary generators. On the contrary, it is quite clear that Mr. Jablochkoff's system may be considered the very reverse of it. If the lamps have worked at all, the tension in the secondary wires must have been such as to make a contact rather unpleasant. A very broad claim attached to the specification does not alter the essence of the invention.

In the following year, 1878, we find several inventions in which induction coils are mentioned. As no other system but lighting in series was considered at that time, it seemed to be the main object of those inventors, as De Meritens and Fuller, to avail themselves of induction coils for the purpose of preventing an interruption of the circuit; the lights being actuated by the secondary circuit, the primary remained intact in case of interruption in any of the lamps.

Messrs. Gaulard and Gibbs conceived an idea of improving the incandescent lamp by means of an induction coil, as described in their patent No. 4942, 1881, in which they desire to utilise the quantity and the intensity of an electric current, the quantity being supplied by the primary current of the induction coil and the intensity by the secondary. Still labouring under a mistaken idea, they took out their patent No. 4362, 1882, sealed on the 13th March, 1883, in which several induction coils are shown in series, the current for the primaries being supplied by an alternating-current dynamo. Messrs. Gaulard and Gibbs imagine that the current in the primary is in no way affected by the work done in the secondary, hence they argue that the number of secondary generators (this new name for induction coils seems to appear here for the first time) can be indefinitely multiplied on the circuit.

Like many people who in search of the philosopher's stone discovered a stone of real value, Messrs. Gaulard and Gibbs, in working out their supposed invention, corrected their mistakes, and developed a system for the economical distribution of electric energy from central stations by means of transformers of alternating currents.

Knowing well all the difficulties and prejudices against which a new invention has to fight its way, I gladly avail myself of this opportunity to express my admiration and regard for the perseverance which these gentlemen have displayed in bringing this system into practical operation.

I may now be allowed to speak of myself. In 1882 I was engaged in experiments on incandescent lamps, and in order to test the vacuum of one of them I wanted to make use of an induction coil. The lamps were connected in parallel, and as a matter of experiment a Ruhmkorff coil, with make and break,

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was put into the circuit in the same manner as the lamps. The fact that this could be done demonstrated, that the active resistance produced by the counter E.M F. prevented short-circuiting of the dynamo through the very small passive resistance of the primary, which would otherwise have occurred. I then commenced a series of experiments with the induction coil as a dynamic apparatus, and ultimately made an application for an American patent, filed January 29, 1883, in the United States Patent Office, which application has hitherto been hidden from public notice for reasons mentioned already on a former occasion.*

I have lately received a full copy of my application from Mr. Thomas D. Lockwood, the well-known electrician of the Bell Telephone Company, who kindly acted as my attorney in this matter. I have no copy of the drawing, but I think the description is perfectly clear without it. The application reads literally as follows :—

"My invention relates to the efficient distribution of electric energy, primarily for utilisation in electrical illumination, although the system is equally well adapted for use in any other application of current electricity, or the energy resulting from the transfer thereof from place to place.

"The aim or purpose of my invention is to provide at any number of specific points or places an abundant supply of electric energy of comparatively low tension or electromotive force, and to accomplish this by a simple and economical method; the supply of electric force or energy at each point being independent of the electrical condition of any other point.

"That the object and purpose of my invention may be fully understood, I will now briefly describe the other methods of distribution which are at present in use, or which have been proposed.

"In the method known as the series system the lamps are placed in the main circuit *seriatim*, or one after another, and a current of high electromotive force thus becomes essential in order to overcome the extra resistance of the circuit including the lamps.

"So far as the effective transmission of electric energy is concerned, such high-tension currents are very desirable, inasmuch as the conductors may be of comparatively small area, and there is very little loss from heating of wires; but their use in the interior of buildings is objectionable on account of the possible danger to life arising therefrom, rendering a perfect insulation (which is at all times difficult to maintain) an absolute necessity, as well as from the dependence which lamps arranged seriatim have on one another.

"A second plan is known as the multiple arc system, and in this the lamps are almost independent of one another, and the electromotive force need not be high; but the expense due to the multiplicity and size of conductors is great if the sectional area of such conductors is made large enough to carry currents of sufficient volume without heating or to keep any heating within reasonable limits.

"It thus appears that if any method could be provided capable of transmitting electric energy of small volume of current, yet of high electromotive force, in the main conductors, while the current in the house conductors, which include the lamps, should be of the requisite strength to fully energise the lamps yet remaining of low electromotive force, the objections inherent in both systems would be to a great extent eliminated.

"The use of secondary batteries has been proposed as a method for the practical achievement of this object; the same being adapted to be charged in series and discharged through the working circuit in multiple arc. Up to the present time, however, the secondary battery has proved in actual work to be untrustworthy, and it is not economical in the reproduction of electric energy. Still, another method of obtaining the desired end would be the employment of intermediate generating stations in the manner hereinafter described—viz.: In each of the intermediate stations where the electrical energy is to be used two dynamo electric machines are employed, one of them wound with a large number of convolutions of comparatively fine wire, and receiving its electricity from the main conductors. It is thus adopted to operate as a motor, and drives the second dynamo machine, which produces currents of any suitable character required, according to the size and number of convolutions of the wire used in its coils.

"I will now proceed to describe fully the method which forms the subject of my invention, and which I illustrate by a diagramatic drawing. I place in the central station, where the electric energy is to be developed, and from whence it is to be distributed, a magneto or dynamo electric generator adopted to produce undulatory currents—that is, electric currents of continuously varying strength. These may also be of alternating direction.

"From this central point, the currents thus developed are conveyed by main conductors through the streets, but these main conductors do not include any of the lamps in the circuit, and do not carry any branch wires. In the places where a light is required, or is to be produced, the main conductors are made to include one helix of an induction coil. A secondary coil is then caused to surround the said helix, and produces the current for the lamps. By inserting an iron core within the primary coil formed by the convolutions of the main circuit an induction coil is formed, but without any make and break apparatus, and adapted to effect results opposite in character to those in which induction coils are generally used; that is, by using a primary coil of high resistance, and a vitalising current therefor of high electromotive force, and constantly varying strength and direction, and a secondary coil of low resistance, currents of great volume, but low electromotive force, may be developed within the circuit of the said secondary coil.

"In the figure a system of distribution is indicated which embodies several modifications of my invention. K is the central station, in which is located a large magneto-electric machine, B, which is adapted to develop currents of high tension, constantly varying strength, and preferably also constantly altering direction. A is a small dynamo electric machine, which supplies the currents for charging the field-magnets of the large magneto machine. In the circuit comprising the generating coil of the small machine A, and the field-magnets of the large magneto machine B, may be placed the rheostat R, of suitable construction, or other suitable adjustable resistance or regulator for the purpose of regulating the strength of the field-magnets of the generator B, by varying the strength of the current flowing in the helices thereof. The current generated in the machine B passes through the main conductors 1, 2, 3, 4, 5, and 6, and through the primary circuit of an induction coil at each place where a light is required.

"Starting from the terminals S, the main circuit passes along the conductor 1 and 2 to the lighted station or group of lamps C, and through the primary of the coil *a* at that station; thence it continues by wire 3 to the group D, and through the coils *b*, *c*, and *d* by wire 4 to and through station E, including coil *e*, by wire 5 to station F, and through the primaries of all the coils included thereat, returning ultimately by wire 6 to the terminal S′ of the magneto generator B.

"In the group represented, at C I have shown four lamps, *l*, of the incandescent class, arranged in as many parallel circuits, *mm′*, all branching from the two main terminals of the secondary coil *a*. This is an adaptation of the multiple arc system of connection. In this case the main conductor is entirely outside the building, and the method of operation as follows:—The current in the main conductor passes through the primary of the coil *a*, exciting currents of low tension and considerable volume in the secondary thereof, which divides between the several branch or parallel circuits thereof, illuminating each of the lamps *r*.

"In the group shown at D, three lamps are shown, each of which is provided with an individual inductorium, the main circuit passing successively through the primaries of the coils *a*, *b*, and *c*, the secondary circuits of each inductorium having a single lamp included in its circuit.

"In the group E, a single induction apparatus is shown, but in the local and secondary circuit thereof I show a number of lamps disposed in series.

* *Electrician*, November 26th, 1886.

"In the group F, I have shown the main conductor as passing into a building, and taking successively into its circuit the primary helices of five induction coils in series, the secondary of each supplying a single lamp. The construction of the coils, as also their arrangement with respect to the main conductors and lamps will, of course, be modified according to the peculiar conditions and requirements to be met; for example, if it be found desirable to arrange the lamp circuits, as in the group C, in multiple arc in the secondary circuit, the secondary coil is made of larger wire than in the other groups, and in group E, where the lamps are *seriatim* in the secondary coil, and where a higher electromotive force is consequently required, the secondary coil is made of a greater number of turns.

"If the lamps used are of the character described in my application for letters patent, filed November 4th, 1882, wherein a light-giving conductor is shown and described, consisting of a hollow cylinder of carbon socketed at either end in solid blocks of the same material, the electromotive force in the secondary coil need not be over twenty volts.

"The illuminating power of each lamp can be modified or regulated in various ways. First, by changing the position of the inner core within the primary coil; second, by varying the active length of wire in either the primary or secondary coils, or both; third, by interposing an adjustable resistance in the lamp circuit; fourth, by shunting the primary coils with an adjustable resistance, which is the most economical method.

"By opening the secondary circuit, or by completely short-circuiting the primary coil, the lamps may be totally extinguished.

"I am aware that it has heretofore been proposed to use electric lamps in combination with induction coils; but in all such cases the object of such combination was diametrically opposite to the object which I have in view.

"The primary circuit was one of low resistance, and intended to convey currents of low electromotive force, while the secondary coil was of high resistance, and the current developed therein of high electromotive force, in order to overcome the very high resistance of the lamps used.

"In my system of distributing electrical energy the arrangement is exactly the reverse. The resistance in the primary circuit is high, the electromotive force generated by the magneto-electric machine at the central station is high, while the electromotive force generated in the secondary coil is a low one; the entire arrangement being for reasons which are fully explained therein."

To this application I should like to add that there are, of course, several sentences in it which I should like to modify to-day, after more than four years have elapsed. Especially have I entirely altered my views with regard to the direct use of continuous high-tension currents.—Yours, &c.,

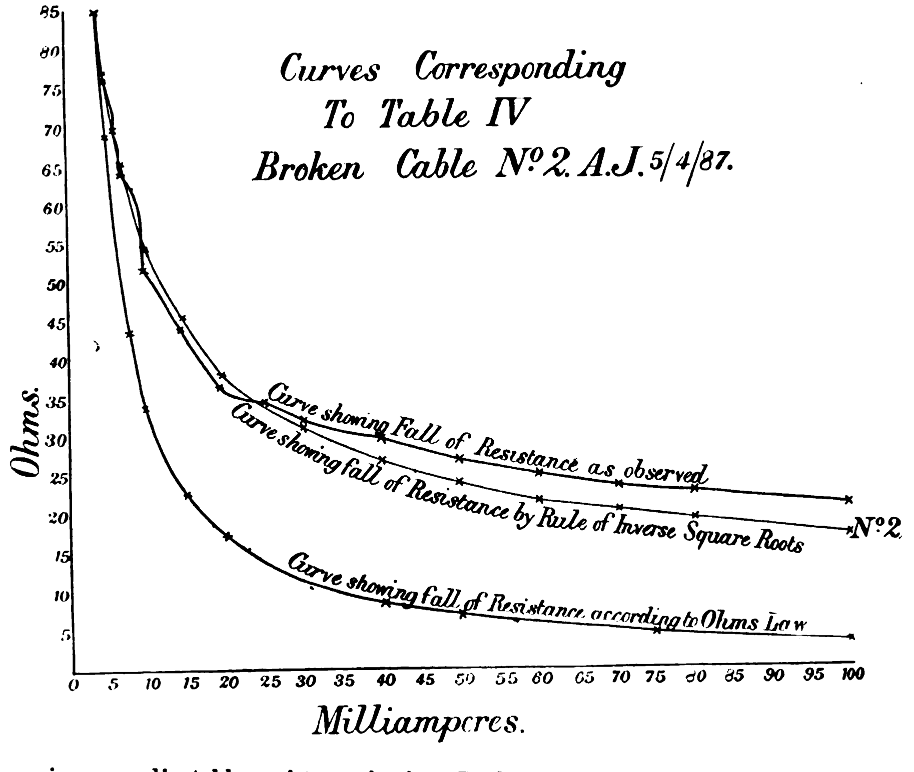
ALEXANDER BERNSTEIN.

The Bernstein Electric Lamp Company (Limited),
9A, Commercial-road, S.W.

KENNELLY'S RULE FOR FINDING THE RESISTANCE OF FAULTS IN SUBMARINE CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read and studied Mr. Kennelly's interesting and instructive paper on the "Resistance of Faults in Submarine Cables" with much pleasure, and consider that he has done good service to the Society of Telegraph-Engineers and Electricians in publishing his numerous, careful, and elaborate experiments. I have plotted out Mr. Kennelly's several cable tests on squared paper, to one scale, and herewith enclose as a specimen, the one corresponding to Table IV., Broken Cable No. 2, showing three curves. One curve in accordance with his observed resistances, a second curve from his calculated resistances, and a third from what would have been the results if no polarisation had taken place, or, in other words, if the fault resistance had been in direct accordance with Ohm's law. In taking such tests it would considerably assist the electrician if he systematically plotted down his observations in this way to one fixed scale of ohms and milliamperes at the time of obtaining them; he would certainly be enabled more readily to see at a glance which observations might be relied upon and which might be conveniently discarded.



The law (or rather we should say the "approximate rule") which Mr. Kennelly has discovered as applicable to the resistance of the fault in a broken cable with comparatively large exposures of conductor is neither very concisely nor clearly expressed by him at the commencement of his paper. It would have been better if he had left the description of his local experiments on tinned iron and sovereigns until the end of his paper. It would have been more to the point and sufficiently explicit if, in stating his two rules, he had simply said:—

Let A_1, A_2, A_3, &c. = the Areas of exposure in square centimetres.

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Let C_1, C_2, C_3, &c. = the Currents passing through fault in milliamperes.

Let R_1, R_2, R_3, &c. = the Resistances of the Fault in ohms.

Then 1st, *When the Area of Fault Exposure is Constant*

$$R_1 : R_2, \&c. :: \frac{1}{\sqrt{C_1}} : \frac{1}{\sqrt{C_2}}, \&c.$$

And 2nd, *When the Current strength passing through the Fault is Constant*

$$A_1 : A_2, \&c :: \frac{1}{\sqrt{R_1}} : \frac{1}{\sqrt{R_2}}, \&c.$$

In the case of Mr. Kennelly's experiment with eight sovereigns, would there not be a liability to a small error due to natural local action between the sovereigns and the bare copper and immersed end of the attached leading wires ?

Mr. Kennelly's figure of the Wheatstone bridge test is neither creditable to him nor to the wood-cutter. Resistances should not be illustrated by indefinite wavy lines, but by clearly-defined angular zig-zag lines, thus (A)

Leading wires are sometimes carelessly drawn in the manner that he has shown his resistances, so (B)

but they are far better thus (C)

A

B

C

It is certainly high time that the committee appointed by the Society of Telegraph-Engineers and Electricians to consider the subject of electrical nomenclature, notation, and diagrams issued their rules and regulations, when we find an electrician like Mr. Kennelly using the Greek letter μ to represent the resistances of the arms of a Wheatstone bridge, and the Greek letter ρ for an adjustable resistance ! Why, the Greek letter μ is invariably used to denote magnetic permeability ; whereas the letters a and b are most commonly used for the arms of the Wheatstone bridge, and the Greek letter ρ for that of the specific resistance of any conductor or material. It is not only *extremely irritating*, but also it unnecessarily occupies the time of the reader when he has first to master the individual eccentricities of the notation of different authors.

Mr. Kennelly on page 508, *The Electrician*, remarks :—" By experiments collected at Table IX., it appears that the resistance of one square centimetre of copper conductor to one milliampere, or what we may call more briefly the resistance per milliampere-square-centimetre, was about 70ω." Would it not have been more exact to have said ...... that the resistance of one square centimetre of *exposed* copper conductor to one milliampere, or, *the resistance per unit density* of current, was about 70 ohms ? The Greek letter ω, although no doubt a very suitable letter for a formula to signify ohms, is scarcely appropriate at the end of a sentence of general text.

Mr. Kennelly in the beginning of his paper refers to Messrs. Winter and Smith's formula. I always understood that it was Winter's formula, and that Mr. Benjamin Smith advocated its application to the Eastern Telegraph Company's cabels when broken. It is as follows :—

$$\frac{n\,B - A}{n - 1} = \text{resistance to fault in ohms,}$$

where n = half the ratio of the number of cells used in the two sets of observations,

B = the total resistance observed with larger number of cells

A = the total resistance observed with smaller number of cells.

For example, if when we get B, we use 40 cells, and when we get A, we use 10 cells,

then $$\frac{n\,B - A}{n - 1} = \frac{\frac{1}{2} \times \frac{40}{10}(B - A)}{\frac{1}{2} \times \frac{40}{10} - 1} = \frac{\frac{40}{20}(B - A)}{\frac{40}{20} - 1} = \frac{2\,B - A}{1},$$

which is simple.

I often applied Winter's formulæ to broken cable tests, but I cannot remember ever getting thoroughly satisfactory results by aid of it. It was never backed up by any careful and conclusive series of experiments like that by which Mr. Kennelly has fortified his formula, and no satisfactory physical, scientific, or other reason deduced from a collected series of independent trials was ever given.

It is to be hoped, now that Mr. Kennelly has produced a formula, backed up and verified by such a large quantity of carefully taken tests, that other electricians in different parts of the world will lose no opportunity that may occur in applying it and in publishing the results of their observations. His rules for testing faults will certainly form most interesting and instructive exercises for electrical engineering students, and I have already set some here to work upon them.—Yours, &c.,

ANDREW JAMIESON.
Principal and Professor of Engineering,
College of Science and Arts.

Glasgow, April 25th, 1887.

INDUCTION COILS GRAPHICALLY TREATED.*

BY GISBERT KAPP.

(Concluded from page 525.)

In the previous article the question of a single coil having self-induction was treated, and it was shown how, by a simple graphic construction, the resultant current and the lag can be found, if the impressed E.M.F. at the terminals, and the constructive data of the coil, are given. We must now extend the method to the case of

2. *Two Coils.*—Let the symbols previously used stand for the primary coil, and let $e^1\, i^1$ denote induced E.M.F. and current in the secondary, their maxima being E^1 and I^1. The resistance of the secondary circuit we denote by r^1 ; and if this circuit contain, besides, the secondary coil, no other portion having self-induction, the three quantities are simply related according to Ohm's law : $E^1 = I^1 r^1$.

(A) *Disregarding the Saturation Term.*—The current in the secondary coil exerts a magnetising force upon the core, which, on the whole, is in opposition to that of the primary coil, although it need not, and, in fact, can never, be diametrically opposed. Let τ^1 represent the number of turns in the secondary coil, then the magnetising force or exciting power in current turns which produces induction, is at any moment $(\tau\, i - \tau^1\, i^1)$; and the total induction is

$$z = \frac{K}{R}(\tau i - \tau^1\, i^1).$$

Since we suppose all quantities to vary according to a sine function, we have also $z = Z \sin a$, where Z is, as before, the maximum total induction. The following equations are self-evident :—

$$e^1 = \frac{\tau^1\, dz}{dt}$$

$$e^1 = \frac{2\,\pi\,\tau^1}{T} Z \cos a$$

$$i^1 = \frac{2\,\pi\,\tau^1}{T\,r^1} Z \cos a.$$

Since the primary current must also be a sine function, we have $i = I \sin(a + \phi)$, where ϕ is the angle denoting the lead of the primary current over magnetisation. The lead of magnetisation over the secondary current is $\frac{\pi}{2}$, as appears by comparing the equations for z and i^1. The secondary current reaches its maximum value I^1 for $a = 0$, $a = \pi$, &c.

$$i^1 = I^1 \cos a.$$

From the above equation, for z we obtain also

$$z\frac{R}{K} = \tau I \sin(a + \phi) - \tau^1 I^1 \cos a.$$

* From *Industries*, April 22, 1887.

Since for $a=0$, $z=0$; we have $\tau \mathrm{I} \sin\phi = \tau^1 \mathrm{I}^1$, and since for

$$a=\frac{\pi}{2},\ z=Z;\ \text{we have}\ \tau \mathrm{I} \cos\phi = Z\frac{R}{K}.$$

From these two equations we obtain the angle of lead ϕ of the primary current over the magnetisation—

$$\tan\phi = \frac{\tau^1 \mathrm{I}^1}{Z\frac{R}{K}}$$

$Z\frac{R}{K}$ is the exciting power which produces Z lines. If the magnetisation remains within certain limits this ratio is constant. It will be seen that the lead of the primary current over the magnetisation is independent of the primary current, and of the number of turns in the primary coil; but depends upon current and turns in the secondary coil. It also increases if the magnetic resistance of the core is decreased, say by employing more iron. The E.M.F. which must be impressed on the terminals of the primary is $e=e_i+e_p$

$$e=\frac{2\pi\tau}{T} Z\cos a + \mathrm{I}r\sin(a+\phi)$$

$$e=E_i\cos a + E_p\sin(a+\phi).$$

This can be represented as a simple sine function

$$e=E\sin(a+\phi+\psi)$$

where ψ is an angle representing the lead of the impressed E.M.F. at the terminals of the primary coil over the primary current; and by reasoning analogous to that employed above, we find

$$\tan(\phi+\psi)=\frac{E_i+E_p\sin\phi}{E\ \cos\phi}.$$

In well-designed apparatus the resistance of the primary circuit is very small, and the E.M.F. required to overcome it is very small as compared to the induced E.M.F. Hence the ratio $\frac{E_i+E_p\sin\phi}{E_p\cos\phi}$ has a very large value, and would be infinitely great if the resistance of the primary were zero. It follows that, in such apparatus, the lead of the impressed E.M.F. over magnetisation approaches $\frac{\pi}{2}$ as the resistance of the primary coil and the magnetic resistance of the core are diminished. It further follows that, if these resistances are very low, the impressed E.M.F. at the terminals of the primary, and the resultant current in the secondary coil, are almost diametrically opposed in phase. The graphic representation of the above formulæ is very easy. Let, in Fig. 3, the radius $\overline{OA}$ of the inner circle represent the effective exciting power $Z\frac{R}{K}$; and that of the second circle the exciting power $\tau^1 \mathrm{I}^1$ of the secondary coil alone, then the hypothenuse of the triangle constructed with these two quantities as catheti gives at once the exciting power $\overline{OI}$ of the primary; and since the numbers of turns τ^1 and τ are supposed to be known, the currents in the secondary and primary for a given total induction are easily found. The E.M.F. in the secondary is proportional to the induction Z. Its maximum value can be calculated by using the formula

$$E^1=\frac{2\pi\tau^1}{T}Z;$$

and this can be graphically represented to a certain scale by the length of the line $\overline{OE^1}$. Imagine, now, the three lines: $\overline{OI}$ representing maximum current in the primary, $\overline{OA}$ representing maximum exciting power, and therefore implicitly also magnetic induction in the core; and $\overline{OE^1}$ representing maximum induced E.M.F. in the secondary, revolving at uniform speed round the centre O, and let them always keep their angular distances; then the simultaneous projections of these lines give at any moment the intermediate values for primary current, induction, and secondary E.M.F. By suitably altering the scale, the projection of $\overline{OE^1}$ can also be made to represent the current in the secondary coil. Let—to the scale chosen for representing E.M.F.'s—the line $\overline{OE_p}$ represent the E.M.F. required to overcome the resistance of the primary, and $\overline{OE_i}$ the induced E.M.F. in the primary, both referring to the maximum current I, then by drawing $\overline{E_iE}$ parallel and equal to $\overline{OE_p}$, we find the impressed E.M.F. on the terminals of the primary $\overline{OE}$, and the lead ψ of it over the current.

So far, then, we are able, from a knowledge of the configuration of the core (giving R), the quality of its iron (giving K), and the electrical data of the coils (giving number of turns and resistances), to determine the currents and E.M.F.'s corresponding to any assumed magnetic induction in the core. But this is not the way the problem is generally met with in practice. We do not find that the induction is given, and impressed E.M.F. or primary current is required to be found, but the opposite. As a general rule, the primary current (series transformer), or the impressed E.M.F. (parallel transformer), is given; and the only question of practical importance is, what E.M.F. and current can be obtained from the secondary coil. The diagram Fig. 3 gives a complete solution to this question, if we enlarge or reduce it, so that the line $\overline{OI}$ or the line $\overline{OE}$ will, to the scales chosen, represent respectively the given primary current or impressed E.M.F.

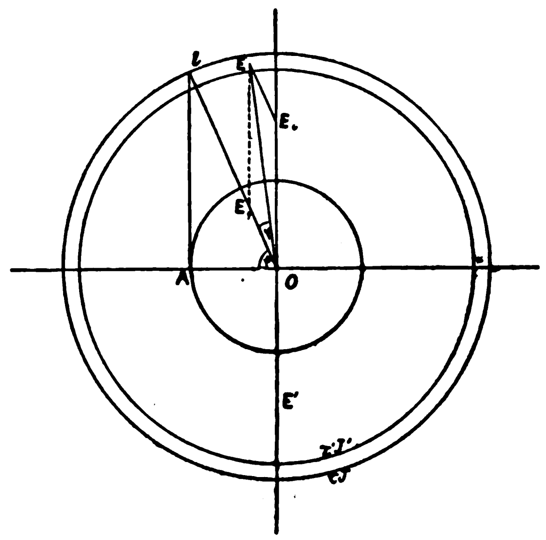

Fig 3.

It is evident that an alteration of current or impressed E.M.F. in the primary will produce proportional alterations in the other qualities (the angles ϕ and ψ, however, remaining unaltered), and we can, therefore, re-draw the diagram so as to suit the given primary current or impressed E.M.F.

The diagram gives implicitly, also, the resistance in the secondary. This is easily seen from the following consideration:—The diagram was constructed on the assumption that the induction Z has a certain value corresponding to the exciting power $Z\frac{R}{K}$, which is graphically represented by the length of the radius $\overline{OA}$ of the inner circle. Then we assumed a certain exciting power of the secondary, and represented it by the middle circle, marked $\tau^1 \mathrm{I}^1$. Now the assumption of Z carries with it implicitly the assumption of a certain E.M.F. E^1 in the secondary, whilst in fixing the circle representing $\tau^1 \mathrm{I}^1$, we have, at the same time, implicitly assumed a certain current I^1 in the secondary; and since these quantities must be related by Ohm's law, we have in reality also fixed the resistance in the secondary circuit,

$$r^1=\frac{E^1}{\mathrm{I}^1}.$$

Now assume the resistance of the secondary to be varied. To fix ideas, let it be increased. This can be represented in

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the diagram by either an increase of the radius $\overline{OA}$, or by a decrease of the exciting power of the secondary $\overline{AI}$, or by both alterations simultaneously. Which of these representations we select depends on the conditions under which the apparatus is supplied with electric energy. If, for instance, it is supplied with a constant current, we must vary both the effective exciting power (and implicitly the E.M.F. and resistance in the secondary) and the secondary current, so that the point I should remain on the outer circle. This will give us a series of triangles O I A, all having an equal length of hypothenuse, but differing catheti $\overline{AI}$ and $\overline{OA}$, which respectively represent the current and E.M.F. in the secondary. Corresponding values of these two quantities can now be plotted in a curve (Fig. 4), which is the characteristic of a series transformer, and which can be used in the same way as the characteristic of a dynamo. It is evident that this curve must be an ellipse, and might, by a suitable selection of scale, be a circle. By adding a scale of resistances R R, the current $\overline{OI^1}$ and E.M.F. $\overline{I^1A}$ corresponding to any resistance r^1 can be read off the diagram, for which purpose it is only necessary to prolong $O\,r^1$ to its point of intersection A with the characteristic.

The characteristic of a series transformer thus obtained is very instructive. It shows at a glance what alterations take place in the E.M.F. and the current (this refers, of course, to their maxima, but their mean values are in a definite proportion thereto) in the secondary circuit if its resistance be varied, say, for instance, by switching lamps in or out. For very large

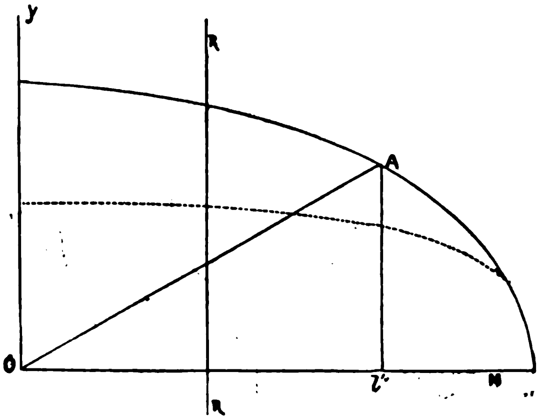

Fig. 4.

values of resistance the alteration of current is proportionately much greater than that of E.M.F., whilst for very low resistances the alteration of current is small compared to that of E.M.F. Thus, if only a few glow lamps are being fed in parallel from the secondary circuit, the switching out of these lamps will not materially increase the pressure in the circuit; but if a sufficient number of lamps be switched on, so as to fully utilise the energy of the transformer, making the product $I^1\,E^1$ a maximum, then the pressure will fall considerably, and the lamps will become dim. On the other hand, we might burn a limited number of low resistance glow lamps in series, and by short-circuiting one after another, the current would not be materially increased; but also in this case the energy converted would be much less than could be obtained with the given tranformer if worked in a condition represented by the middle portion of the characteristic. It is interesting to note that, even if the secondary coil be completely short-circuited, the current in it does not become very great. Roughly speaking, it is twice the current at which the transformer develops the maximum energy. For commercial reasons, it is evidently necessary to work transformers at or near the point of maximum output, and a glance at the curve will show that this class of apparatus (series transformer, with a core sufficiently large to avoid approach to saturation) can never be self-regulating if so used. It can only be made approximately self-regulating if used under conditions represented by either extremity of the characteristic; but as, under these conditions, the output is very small, this is not practicable from a commercial point of view. It will be shown presently that transformers with small cores in which saturation is reached are in this respect slightly better, although not nearly so perfect, as parallel transformers.

If the condition of supply is constant impressed E.M.F., the point E in Fig. 3 must always remain on a circle described with $\overline{OE}$ as radius. In this case, the process of finding the characteristic is slightly more elaborate, but presents no special difficulty. We assume different values for the current in the secondary, and keep the effective exciting power for the present constant. Thus the point I in Fig. 3 assumes different positions on the line $\overline{AI}$ and its prolongation. To each position corresponds a certain value of $\overline{OE_\rho}$, all the points E_ρ lying on a vertical line, whilst $\overline{OE_\iota}$ remains, by reason of constant total exciting power, evidently constant. The corresponding points E lie, therefore, on the lines $\overline{E_\iota E}$, each of these lines being drawn parallel to the corresponding line $\overline{OI}$, and equal to the corresponding values of $\overline{OE_\rho}$. Since this alters the distance of E to O, it is necessary to make a correction in every case, by increasing or diminishing all the quantities proportionately, so as to bring back the point E to the circle representing the constant impressed E M.F. The effect of the correction

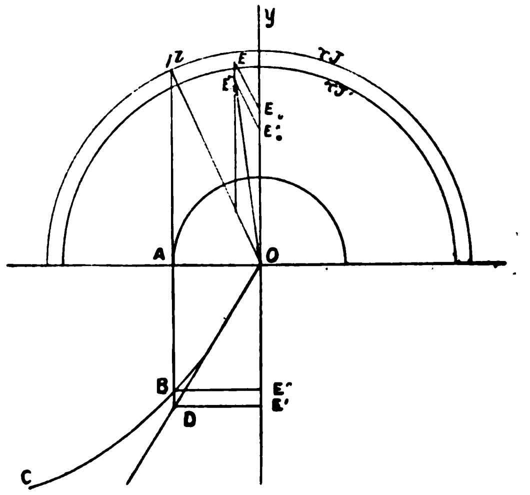

Fig 5.

will be to diminish the E.M.F. in the secondary for increasing currents; but if the resistance of the primary be very small, the quantity $\overline{OE_\rho}$ in the diagram must in each case also be very small, and the correction and consequent alteration of E.M.F. becomes trifling. Practically, the characteristic of a parallel transformer is, therefore, a straight and horizontal line, and such a transformer will be almost perfectly self-regulating for constant pressure.

(B) *Taking the Saturation Term into Account.*—The effect of saturation is to make the induced E.M.F.'s E^1 and E_ι not strictly proportional to the effective exciting power, but rather smaller. The only alteration in diagram Fig. 3 will therefore be that the point E^1 will lie inside its former position, and the point E_ι will also be shifted nearer to the centre. Let O C, in Fig. 5, represent the characteristic of magnetisation, drawn to such a scale that the ordinates represent the induced E.M.F. in the secondary (which is evidently proportional to Z), then, by altering them in the ratio of τ to τ', these ordinates can also be made to represent the induced E.M.F. in the primary. If the increase of magnetic resistance did make itself felt equally throughout the whole period, the induced E.M.F. in the secondary corresponding to the exciting power $\overline{OA}$ would be represented by the line $\overline{OE''} = \overline{AB}$, instead of the line $\overline{OE'} = \overline{AD}$, as before; and the induced E.M.F. in the primary would be represented by the line $\overline{OE_\iota''}$, instead of $\overline{OE_\iota}$, the ratio $O\,E_\iota''/O\,E_\iota$ being equal to $O\,E''/O\,E'$. The lead of impressed E.M.F. over the current in the primary (ψ in Fig. 3) has, in consequence of these alterations,

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been somewhat decreased, and the impressed E.M.F. $\overline{OE_0}$ in the primary is also smaller than it would be if it were permissible to neglect the saturation term. Since, however, the effect of saturation is not felt at and near the point where the magnetisation of the core passes through zero, the true value of the E.M.F. in the secondary lies between the points E' and E'', and that of the impressed E.M.F. in the primary between the points E and E_0. Owing to hysteresis, the true values will be rather nearer E'' and E_0 respectively, and might, for practical purposes, be considered to coincide with these points.

It is interesting to investigate the influence of saturation on the characteristic of a transformer. If the supply be at constant E.M.F., we assume, as before, different positions of the point I on the line A I, and its prolongation; ascertain the corresponding positions of E_0, and correct for constant impressed E.M.F. Owing to the relatively greater value of E_ρ, the corrections will be rather larger than before; but on the other hand, the influence of these corrections upon $\overline{OE''}$ will be relatively less, since the intersection of the line A D takes place with the curve at B at a more obtuse angle than with the straight line at D. On the whole, therefore, the introduction of the saturation term, whilst lowering the characteristic of a parallel transformer throughout, need not necessarily cause it to depart more from a straight and horizontal line. To work with a high degree of magnetic induction is, therefore, compatible with the attainment of a nearly constant E.M.F. in the secondary circuit. If the supply is on the series system, with a constant current, a construction analogous to that described above gives a characteristic consideraly below that found previously near the origin, and coinciding with the previous curve at the more distant points. This curve is indicated by a dotted line in Fig. 4.

It will be seen that it contains a somewhat longer portion where the slope is only slight, and this indicates that the variation of E.M.F. in the secondary has been somewhat reduced by reason of saturation. A series transformer, with a small and over saturated core, might therefore be made to regulate within somewhat wider limits than one where the core is large; but the regulation can never be perfect, and the output obtainable with a given weight of copper must be less than in a transformer which has a core large enough not to become over saturated.

THE MEASUREMENT OF THE INTENSITY OF THE MAGNETIC FIELD.

M. Eric Gerard has devised an instrument, which he calls a "magneto-dynamometer," for the measurement of the intensity of a magnetic field without the aid of a ballistic galvanometer. The necessity for some more convenient and more accurate method than that at present in use for determining this important quantity has long been apparent, and if the indications given by M. Gerard's instrument prove to be as reliable as its use is certainly simple, the magneto-dynamometer will be an invaluable addition to the apparatus of the testing room.

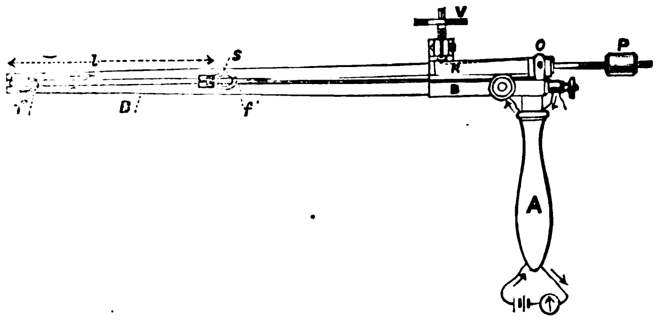
The principle upon which the instrument is based is that of sending a current of known value C, through a conductor of known length l, and noting the force exercised upon it by a magnetic field. If the quantities be given in C.-G.-S. units we have then

$$f = H\,C\,l \text{ dynes.}$$

C and l are known, and the measurement of f at once gives H. The application of this principle is made in what must be admitted to be a very ingenious manner. The instrument is shown in the accompanying figure.

It consists of two long and narrow strips of brass fixed at right angles to the handle A, the upper strip being hinged at O and provided with a counterpoise, P, which can be adjusted so as to cause the upper arm just to stand clear of the lower arm B. The two arms are, however, joined together at the extremity f by a flexible wire, and a pair of sliders, S, moving on a graduated scale, also connect the arms in a similar manner at a second point. The object of this arrangement is to enable a current to be sent along the fixed arm, and back through any required length of the movable arm. After crossing at the slider S the circuit is completed through an insulated wire laid along the arm B. At R there is a spiral spring tending to oppose the separation of the arms, and provided with a micrometer screw, by means of which the force required to restore the arms to the parallel position can (after proper calibration) be read off.

The *modus operandi* is as follows :—The arms being placed in a position in which they are at right angles to the direction of the field whose intensity is to be measured, the movable arm is first balanced by means of the counterpoise P. A current of known strength is then sent through the arms, and the screw V is turned until balance is restored, the reading being taken from the micrometer scale. The length l is made adjustable, merely in order to give the instrument a greater range; for strong fields l can be made shorter, and for weaker fields it can be lengthened.



M. Gerard points out that there are several obvious sources of error in the instrument, but he contends that for practical commercial use the errors are entirely negligible. Apart from the question of mechanical construction, the chief sources of inaccuracy are, (1) the force exercised by the earth's field, (2) the force of repulsion between the currents in the two arms. In *L'Electricien* M. Hospitallier works out a numerical example of the result of these errors, and shows that in a field of 500 C.-G.-S. units, with a current of 1 ampere in the instrument, the error is only 0·25 per cent. But it must also be remembered that the trustworthiness of the indications depends upon the accuracy with which the current in the arms is known. M. Gerard's instrument, at any rate, possesses in a high degree the merit both of novelty and of ingenuity.

THE AMERICAN NATIONAL ELECTRIC LIGHT ASSOCIATION.

DISCUSSION ON ELECTRIC MOTORS.

At the recent meeting of this Association Mr. W. Baxter, jun., read a paper on "Electric Motors," which, however, we are sorry not to be able to find room for. The discussion which ensued was of a very practical and interesting character, and is given below.

Prof. Edgerton : In the paper we have just heard read there is a suggestion which it seems to me should occupy the attention of the convention, and that is, in regard to the cost of supplying the electric current for motor purposes. What is wanted by our electricians and those who dispense and sell the current is to know whether there is going to be a large demand. If there is going to be a demand, and if it is to be permanent, I do not think there is one of you but will at once prepare for the work. Now, judging from the correspondence we have, and if we look over the field, I do not believe any man can shut his eyes to the fact that where one customer will use electric light, ten men—yes, a hundred men—will use electric power. The motor has also this advantage as to permanency. The electric light is, to all intents and purposes, a luxury. Your business man, as soon as trade falls off, says : "Take my lights out, I am done with them for the present ; I can get along with gas for the time being." If he cannot get gas he can get something else. But when you take a motor and put it into a man's place and put money in his pocket, and give him something which is better for him, you have got that man's business as long as it continues. For that reason, I think, the electric light companies have the prospect of a large new business with a royal percentage of profit coming in. I want to suggest that this convention appoint a committee to take in hand the matter of the price of furnishing current by the electric light people, and to prepare a list or scale of prices that would be mutually satisfactory, the committee to offer it at our next meeting.

Mr. De Camp thought the suggestion a good one, and stated that the price they were getting for motor service in Philadelphia was 65 per cent. of that for electric light. They had no definite data to go on, but were charging at the rate of $5 per month for four small sewing machine motors.

Mr. Duncan said he had had some little experience in the distribution of power with motors. They were running in Pittsburg altogether sixteen motors varying in size from a half to ten horse-power. These motors were all running, with one exception, upon the direct incandescent current. The question as to the relative cost of light service and power service was not sufficiently advanced for definite and equitable settlement. He had no hesitation in stating, for the information of the Association, that he could obtain from the distribution of power twice as much as he could for light. They had no difficulty in placing these motors at all. The demand came to them, they did not go after it. Furthermore, the satisfaction obtained was such that they had on record in their office statements to this effect: Parties who have used these motors for six

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months, as against steam or gas power, would be willing to pay 25 per cent. more for the electric service. Of course, that was gratuitous on their part, for he should certainly ask them next year to step up instead of down.

As regarded the maintenance of motors and the amount of service required to keep them in order, he would say that as far as he could see, and as compared with an arc system, the motor requires no particular attention at all. An arc light did require particular attention, and from his experience he would say that the carbon trimmer, after a little training of a week with a motor in the shop, could, if he were at all a competent man, make a round to all the motors in service and keep them running. In Pittsburgh they simply made a round twice a week to every motor in service. The man made a report. It formed part of his duties, the same as his carbon setting and the report on his lamps. He could not see why, where a light station was properly equipped for doing business, there should be any increase of force or attendance necessary whatever for the distribution of power—say up to 100 motors in service. That was, where the district was already covered by the light wires. Outside of that, it was a matter of development, the same as anything else. "I think we have arrived at that point where we can safely say that in large cities the distribution of power by means of electricity is one that will pay to run either as a separate plant or in connection with the lighting business. It is simply a question whether the lighting people are going to keep that business to themselves, or whether they are going to allow somebody else to step in and take it as a separate business. In regard to the amount of investment and the relative cost, I would simply say that after we had placed four or five motors we arrived at the conclusion that it would be a very good thing for the customer to buy the motor—in other words, it would be a very good thing to have the customer interested in the business. I may say that so far the majority of our motors are owned by the subscribers, and that one person in the employ of each concern gives an eye to the motor. We make the inspection, and see that they do not crowd on more work than we guarantee when we make the bargain."

Mr. Upton said that in Boston the motor subject had been satisfactorily taken up and dealt with. The Edison station there had 300 horse-power, and one-third was now used in transmitting power electrically. It had proved a valuable addition to the economy of that station, much larger than they could possibly conceive. He believed that all central lighting stations should put in motors. The additional cost was small; in some cases running all the time it was simply the cost of the coal used, with possibly the wages of a few inspectors. In fact, the whole question had been satisfactorily settled in Boston, where they were running elevators two miles from the station, both passenger and freight, with most perfect success.

Mr. Harding stated that in Boston they were getting $125 per horse-power per year for a day of 10 hours. They preferred the contract system as the only sensible one to use with the supply of intermittent power. Another point he would insist on strongly was to sell the motors and not to rent them. They had sold every motor they had put out in the city of Boston. As a result, the customer took excellent care of the motor. When the motor was placed in a shop, a good reliable man was selected to take charge of it there, fill the oil cups, start it in the morning, &c. Then they had an inspector who went round at certain intervals to see that everything was all right. Another point was not to have the motor overloaded. In Boston with about 40 or 50 motors they were deriving an income which was paying the local Edison company on its total original capital of $100,000, 8 per cent. from power alone. Every day men were coming to the motor company wanting to buy motors. The motors were now called for in very much larger sizes, at pesent more 10 horse-power than any others, but 15 and 20 were in demand. These motors had a guaranteed efficiency of 90 per cent., and the horse-power was guaranteed. In one case, where a motor had been overlooked, it ran for seven weeks without inspection or attention, but he advised systematic inspection, which would only take one minute in each case. As regarded elevators, there was certainly nothing in machinery, say up to 20 horse-power, that the motor would not do. They were now running the largest elevator in Boston, a freight elevator 12ft. long, 6ft. across, going 60ft. a minute. They were also running a passenger elevator going 100ft. a minute, and both were run from the same motor of about 15 horse-power. He thought it desirable to have data collected as to power required, &c. As to fuel, in Boston they were burning cheap fuel, three tons of screening, costing about $2, and one ton of Cumberland, mixed, costing altogether delivered about $2.50 a ton. They used the Jarvis setting, and from that got excellent results. A large proportion of the business was elevator work in the wholesale part of the city. About 4:30 it was almost entirely deserted, and so the power business began to go off as the lighting came on. It would be different in different cities. They were not using one-quarter of the current they could obtain from the station. The circuit upon which motors were running in the day ran lights also.

Mr. Kerr held that only when the incandescent wires embraced the residence portion of a city would they be able to sell much beyond their actual capacity. For instance, in one town where the total call for incandescents would be 7,000 lights, the business portion took only 400 lights. Now, when they got the 7,000 lights, including the big residential area, they could rent power or light far above the station capacity. Companies that went out into residence districts found that they did not have to increase their stations so rapidly as their rented capacity would indicate. He know stations in this way running 1,300, 1,400, and 1,500 lights from two 500-light machines, because there, if a man went to the church, theatre, or hall, he did not burn his light at home, and if all the lights were going in one house, it was because a party was going on there, while all the lights in the neighbouring houses were turned off, the people being at the party.

THE WRECK OF THE "VOLTA."

In addition to the extract from the letter which we were able to give in our last issue, we have before us other information containing accounts of this disaster. One of the survivors writing home says :—

"We were just swinging the life boats when she gave an awful lurch, and down she went. I do not know what happened after that. The masts and part of the bows were still out of the water, and the sea breaking right over. I was swimming about for a quarter of an hour, when suddenly I knocked up against something which I fround to be the bows of the ship. I managed to crawl up, more dead than alive, and clung there till daybreak, and then, what a sight! I shall never forget it. We were on a rock-bound coast, and it was blowing a tremendous gale. I found that some of the men had managed to get ashore, and were standing shivering on the rocks. The sea was increasing, and so I thought if I stayed longer where I was I should soon get washed away, and I told the others who were near me that I was going to make a swim for it, and asked if any one would come with me, but no one would, so I jumped off, and then came the struggle between life and death. I managed to reach the rocks, but could not land, as the suction was dragging me out to sea; then some one flung me a rope from the shore, and I managed to catch it, and remember being dragged on shore, and then I think I must have fainted, for when I came to myself I found some of the men watching me. I asked them if anyone had gone for assistance, and they told me the town was 15 miles off, so I got one of the Greeks to come with me as a guide, and started off at once for the town. When we got about half way, one of the shepherds we met lent me his donkey, or I do not think I could have got to the town. I reached there about 10:30, and wired across to Syra to send assistance." The letter goes on to speak of the kindness that was received from the inhabitants, and then to describe that "about 4 o'clock a steamer came from Syra, lowered a boat and sent to the wreck, and if ever a boat was well handled she was. They saved 13 out of the 15, the other two poor fellows being drowned. . . . We took the names of all the men saved and found of the 13 lost among them our dear old captain. He was like a father to us all."

The following account of the wreck is translated from an Athens newspaper :—

"Yesterday morning, just before ten o'clock, a short urgent telegram was received here by the manager of the Eastern Telegraph Company from Miconos announcing the total wreck of that company's repairing ship, the "Volta," on the rocks there at Cape Mersinis. The Greek Steam Navigation Company immediately ordered their Captain J. B. Belissarius to place himself and ship, the "Karteria," under the orders of Mr. Binney, as it appeared from the contents of the telegram that several of the crew were clinging to the masts and rigging of the already submerged ship, and that unless help were immediately sent they would all be lost. With all haste everything was prepared to start, and at 11:15 a.m. we steamed off. I say we because I happened to be on board at the time, and was allowed, therefore, to accompany the rescuers. Besides Mr. Binney there were also Messrs. T. Bouffis, the Greek Steam Navigation Company's inspector, A. Mavrogordato, a director, and many other gentlemen, the latter attracted thither through simple curiosity. We shaped our course for the north-east of the island in our search for the wreck, and on rounding the Cape Mersinis we could make out the mainmast of the sunken vessel, and shortly after the foremast. On a nearer approach, thirteen men were seen desperately clinging to the yard arm. The state of agitation this awful sight caused to all on board is imaginable only—it cannot be described. On the heights above the rocks on which the ill-fated 'Volta' ran at full speed were more than thirty of the survivors and natives of Miconos, who were helpless to render any assistance to their shipmates drowning under their very eyes. Our captain immediately gave orders to prepare our largest boat, which in a few minutes was ready for launching. The weather, however, was fearfully stormy, the waves and breakers running mast high, and there apparently was more danger to the rescuers than actually to those clinging to the rigging. All our eyes were fixed on the boat (into which ropes and life buoys had been placed) in order to see by whom it would be manned, as the danger was extreme, and only at the known risk of their own lives could the gallant rescuers hope to succeed. As soon as the boat was quite ready two of our own crew sprang forward, and after stripping themselves, jumped into the boat. Five others, extra hands, on seeing this, also stripped, and followed the two first into the boat. The names of these gallant fellows are as follows :—Constantine Micaros, a native of Psarà, a fine young fellow, 26 years of age, and on whose life an aged mother and three sisters depend; Mike Bouriss, also a native of Psarà; two brothers, named Samiottis, from Hydra; S. Dimoulakis, Michael Nikitas, natives of Milo, and S. Betmiss, another Hydriote. It is utterly impossible to exaggerate the bravery of these seven heroes, rushing to an almost certain death, so great was the apparent danger. At 3 p.m. precisely the boat left the ship. When about thirty yards from the wreck, the life buoys were thrown overboard, and were driven towards the yard arm, on which the thirteen survivors were, and after making one end of the rope fast to the rigging, one by one seven of them were floated to the boat, and dragged in almost dead. We in the 'Karteria'—under full steam the whole time, and every minute expecting ourselves to be washed on to the rocks—suffered the most agonising suspense during the hour this operation took to perform. At 4 o'clock the boat was alongside again, and the force of the waves was so great that it was feared the boat would be crushed, but by dragging her to the bows the seven Englishmen were at length got on board. The boat immediately pushed off again, but with five men only, that number being amply sufficient. The weather appeared to be getting worse, if possible, and the greatest fears were entertained for the boat's safety. To form some idea of the state of the weather—for an open boat to live in it—I must tell you

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that when we on the 'Karteria' were beam on to it the waves broke right over the ship, even drenching those on the bridge, whilst we were also but a very short distance from the rock-bound coast. We in the meantime tended the seven already rescued, who were half dead and benumbed with cold, rubbing them to produce re-circulation, and giving them brandy and hot tea to warm them internally. At a quarter to 5 the boat was again alongside, and although several times it was nearly capsized, it succeeded in bringing off in safety the remaining six; but every eye was fixed upon it in the deepest anguish when it left the wreck to return, as one moment it rose on the top of a towering wave and then disappeared in the trough of another, as if it could never keep afloat. Eventually these were all safe, and tended with every care by Messrs. Binney, Mavrogordato and Bouffis, as well as by the other gentlemen on board. Three men still remained in the bows of the "Volta," which were just out of water, and had succeeded in getting a rope fastened to the shore. One of these, the first, landed safely; the second, in trying to land himself, fell and killed himself on the jagged rocks; whilst the third was swept off into the sea in endeavouring to seize the rope. The ss. "Volta" was coming to Sira from Tenedos and Chio, where she had been to repair the cable, and she ran on the rocks shortly after three in the morning. The Greek sailors and some others on board, directly the ship struck and they saw she was sinking, threw themselves into the sea, and swam or were washed to land. One only of these was lost. Twenty-seven of the crew were thus saved and all still in Miconos, and, with the 13 saved by us, leave 12 or 13 unaccounted for, and there is no doubt that they have all been drowned. Amongst this number is the captain, W. J. Dunn, the assistant electrician Blum, and 10 or 11 others. The 13 saved by us owe their lives to our brave Captain Belissarius, who so ably managed the 'Karteria,' and to the almost unparalleled heroism of the seven sailors who so willingly risked their lives. We were not a moment too soon to the rescue, as we have since heard that an hour after both masts were broken off and carried out to sea.—B. Sira, April 19, 1887."

COMPANIES' MEETINGS & REPORTS.

The West Coast of America Telegraph Company (Limited).

The tenth ordinary general meeting of this Company was held on Tuesday, the 3rd inst., at 50, Old Broad-street, E.C., under the presidency of Mr. Alfred Marshall.

The SECRETARY (Mr. Fred. L. Robinson) read the notice convening the meeting, and the minutes of the ninth ordinary general meeting, held on the 2nd June last, which were confirmed and signed by the Chairman as correct. The report and accounts were taken as read.

The CHAIRMAN, in moving the adoption of the report and accounts, said: I will confine myself to making a few general remarks relating to them. You will have noticed that the chief feature of the report presented to you is that there has been a decrease in the working expenses of our steamer, and the second feature of importance is that our gross earnings have shown a slight decrease from those of the previous year. The decrease in the expenditure is caused by the great economy used by our captain and our servants on the coast. The decrease in the earnings is attributable to the great depression in trade, and to the loss of exchange that we have suffered. You are all acquainted with the fact that a long and disastrous war has been carried on during the past few years, and although this is at an end, and although it has ended in the victory of Chili, the country with which we are chiefly concerned, still it has caused a great drain on the resources of the country, and naturally commerce has felt the result of it. At the same time the Chilian Government has, in order to raise the funds necessary to carry on this warfare, adopted the rather suicidal policy of issuing paper money. This has told on the exchange, and whereas in former years the dollar was worth about 4s. it has gradually during the last year dwindled down to about 1s. 10d. I am happy to be able to mention that a reaction has taken place, and notably since the month of October last, and that since then our earnings have correspondingly increased. If it had not been so we should not probably have felt in a position to divide the last dividend which we distributed among the shareholders in January. But not only has the exchange improved since October, but there has also been a marked revival in our traffic, which we can only attribute to the gradual improvement of trade generally. We have also been aided by another but otherwise unfortunate circumstance. I refer to the cholera, which has been communicated from the Argentine provinces to Chili, and has necessitated the cutting off of communication by steamer between Chili and Peru. This has thrown a great deal of traffic our way. Even letters were not sent by post, so that any communication that had to be made between Valparaiso and Lima had to be carried on by telegraph. This you will have noticed gave us a very much larger traffic in the first months of the year. The Minister of Finance in Chili has lately adopted measures which it is hoped, and very confidently hoped, will lead to the restoration of the currency within a measurable time. These measures consist in purchasing a certain amount of silver every month, and in destroying a certain quantity of the paper money, which has so much tended to depreciate the currency. We may, by these measures, hope gradually to reach again an exchange which is somewhat equivalent to the value of silver, which is the currency of the country. Before putting to you the resolution I would give you the welcome intelligence that during the first three months of this year our gross earnings have been £5,000 in excess of those of the first three months of the year 1886, and if this satisfactory state of our traffic continues, we confidently hope not only to materially strengthen the position of this Company by adding an important amount to our reserve, but also to distribute dividends at least as large, if not larger, than any that have been distributed during any year that this Company has been in existence. With these few remarks, gentlemen, I beg to move the adoption of the report and accounts.

Mr. THOMAS FIELDEN CAMPBELL seconded the motion.

In reply to Mr. Martindale, the CHAIRMAN said that the remark which the auditor appended to the accounts was the same as that which had been made on previous occasions as to the investment of the Company's moneys in its own debentures. He might mention, however, that since the report was drawn up they had made an investment of their reserve fund in a more convertible security. They had lately invested £5,000 in the Debenture Stock of the Southern Mahratta Indian Railway which had been guaranteed by the Government. It was undoubtedly a good security and convertible at any moment.

The motion was agreed to *nem con.*

The CHAIRMAN next proposed the re-election of the retiring Directors, Messrs. Thomas Fielden Campbell and Henry Roberts, which, having been seconded by Mr. MARTINDALE, was also agreed to unanimously.

Mr. MARTINDALE asked whether it was intended to elect a Director in the place of Mr. MACANDREW.

The CHAIRMAN said that they had determined not to do so, for the present at all events, the existing Board being quite equal to the carrying on of the business of the Company.

The auditor (Mr. J. Weise) having been reappointed, a vote of thanks was passed to the Chairman and Directors, which terminated the proceedings.

Great Northern Telegraph Company of Copenhagen.

The following is an abridged report of the general meeting held at Copenhagen on the 23rd April, under the presidency of Mr. F. Zahle:—

Mr. C. F. TIETGEN (the Chairman), in addressing the meeting with regard to the Company's general business during the working year of 1886, referred to the Company's cables and the land lines in connection with the same. The state of the cables had, he said, been satisfactory during the year. There had of course been a certain number of interruptions, but the repairs had been speedily and effectually completed by the Company's own two steamers, and the opportunity had on every occasion been seized at the same time to strengthen the cables in the most exposed places. Thanks to the Company's general system of duplication, the traffic had at no time suffered any interruption or delay. The repairing steamer in the Far East had, besides, undertaken cable repairing work for other parties, and earned a profit which had contributed to reducing the working expenses of the steamers to a minimum. With regard to the duplication of the Swedish and Russian land lines referred to at the last general meeting, he had to report that they were in perfect working order, and this duplication between Petersburg and Gothenburg respectively had proved of great importance as regards the speedy transmission of the Company's traffic. The Russian Administration had further decided to adopt the system of the Wheatstone instruments at all their international stations on the Wladiwostock line. The necessary instruments had been manufactured in the Company's workshops at Copenhagen, and their installation had now been commenced with the assistance of the Company's staff, of whom the Russian Administration had engaged a certain number as operators at the different stations in Siberia. By these means improved correctness and speed would be given in the transmission of the Company's traffic between Europe and the Far East, which is already very fair, considering that traffic was passed on an average in three or four hours. In China the development of the Imperial Government land line system had progressed moderately. The construction of the line from Seoul, the capital of Corea, to Fusan, the landing point of the Company's cable to Japan, was progressing, but it had not yet been completed. Several land lines in the Mantchuria, towards the Russian frontier, had been pushed on, and the line running along the Yangtse River had been extended beyond the town of Ichang. The traffic receipts, as had been foreseen at last year's meeting, had diminished, say for 1886, to the extent of about £27,000, as compared with those of 1885. This had in a great measure been owing to the tariff reductions established by the Berlin Conference, but the effects of the continued depression of trade had also made themselves felt. The experience of the new rates had, however, not been long enough to enable the Company to judge with any amount of certainty about their future influence upon the revenue. The changes introduced by the Berlin Conference had had the effect of causing much labour to the administration during the past year. It had been necessary not only to modify the Company's system of tarrification and journalisation of telegrams in all their stations, but also to revise most of their conventions and arrangements with other administrations. This work had, however, been done in good time and in a satisfactory manner. Since 1883, when this Company duplicated the lines from Wladiwostock to Nagasaki and Shanghai, and when it was decided that the Company's Shanghai-Hongkong line should be duplicated by the Eastern Extension Telegraph Company for their own account, there had been two telegraph stations situated close to each other belonging to and worked by this Company and the Eastern Extension Company respectively, whilst as per previous agreement the revenues were equally divided. Such an organisation appeared more costly than strictly necessary, and it had therefore during the year been agreed to amalgamate the interests of the two companies in this respect also, so that in future a joint Hongkong Station will be managed by the Eastern Extension Company, where this Company is represented by a Danish controller and three Danish operators, whereas the Shanghai Station is managed by this Company with an English controller and English operators representing the Eastern Extension Company. But satisfactory as this arrangement would be from a practical and economical point of view, he was glad to say that a more important factor had been brought into the question—namely, a more intimate alliance between the two companies in their Chinese relations than had previously

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existed. The object would therefore now be jointly to defend the companies against the Chinese competition, which constituted violations of our Chinese concession, which he had referred to on a previous occasion, and to do this by making common application to the Chinese Government and the Chinese authorities in order to maintain the legitimate rights of the companies in accordance with the Concession granted in 1881. For this purpose the companies had applied to their respective Governments in Europe, who had assured them of the assistance of their legations at Pekin; and the representatives of the two companies lately returned to China from Europe, where they had received the fullest instructions, were now either at Tientsin or Pekin in order to lay their case before the Government, and endeavour to arrive at a solution which might be considered satisfactory to all parties interested. He thought it premature at the present moment to enter further into the question, but he felt confident that the Chinese Government, on the present occasion, when they were no longer preoccupied by urgent and grave State affairs, would no longer adjourn the discussion relating to the companies' demands, but would give them due consideration, and that they would endeavour to find the means to meet those just claims. Although it might appear superfluous, he thought that owing to remarks made elsewhere, he ought to state that the new arrangements with the Eastern Extension Company did not exceed what he had already stated or the terms of previous agreements, and that thereby neither the general organisation nor the proprietorship of either company's cable business was affected. In referring to the balance sheet, the speaker said that it was true that as against the falling off of traffic receipts, already referred to, there might to a certain extent be set off the increased receipts under the head of sundries and the reduced expenses, but it must be remembered that the former was of a perfectly sporadic nature—the Company had been fortunate in acquiring these extra profits last year, but without any reasonable probability of their continuing—and the latter was more apparent than real, and mainly owing to readjustment of the dollar exchange formerly maintained by the Company for book-keeping purposes, and as most of the expenses in the Far East were paid in that coin the change had now become necessary. As it was, the Directors proposed to the meeting to deal with the balance remaining after payment of all general and ordinary charges for interest and amortisation of debentures, and also of the usual 5 per cent. interim dividend during the past year as follows:—£37,500 to be divided amongst the shareholders as an extra dividend of 2½ per cent., making the dividend for the year, including the interims paid, 7½ per cent; £2,777. 15s. 7d. as endowment to the pension fund of the staff; £55,555. 11s. 1d. to be added to the reserve fund; and £31,586. 3s. 3d. to be carried forward to next year's account. Owing to different circumstances, such as the pending Chinese negotiations, the continued depression of trade and shipping, and the aspect of the political horizon, which for some time past had been far from cloudless, the Directors had considered it their duty to adhere to a prudent financial policy, and he trusted that the shareholders would agree with them if they remembered that this very Reserve Fund was in existence, amongst other things, for assisting in the equalisation of dividends in those future years in which the revenue might not suffice to pay a respectable rate.

Without discussion the propositions of the Directors were unanimously adopted, the accounts were passed, and the usual discharge was given to the Directors.

The CHAIRMAN feelingly made mention of the death of C. A. Broberg, Esq., one of the Directors, which had occurred in the course of the year. He had been a Director since the foundation of the Company and had always been hopeful of its success. The Directors had invited A. Garde, Esq., formerly Governor of the Danish West India Islands, and who had acted as auditor for the shareholders, to join the Board.

Col. V. Heskjær and A. Garde, Esq., were unanimously re-elected on the Board.

A. Berner, Esq., and S. Bille, Esq., were likewise unanimously re-elected as shareholders' auditors.

The Brazilian Submarine Telegraph Company (Limited).

Report and accounts of the Directors for the half year ended 31st December, 1886, to be submitted to the twenty-seventh ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, E.C., on Wednesday, the 11th inst., at 12 o'clock.

The revenue for this period amounted to £95,831. 4s., and the working expenses to £12,935. 17s. 5d. After providing £11,555 for debenture interest and sinking fund, and £1,986. 16s. for income-tax, there remains a balance of £69,353. 10s. 7d., to this is added £2,174. 14s. 6d. brought forward from 30th June last, making a total of £71,528. 5s. 1d. First and second interim dividends amounting to £39,000 have been paid, and £25,000 transferred to the reserve fund, leaving the sum of £7,528. 5s. 1d. to be carried to the next account. In accordance with the provisions for repayment of the first issue of debentures, dated 31st July, 1884, 371 bonds, representing £37,100, were drawn on the 26th April last, for payment at par on 31st July next. The various sections of the Company's lines are in good working order.

Submarine Cables Trust.

Report of the Trustees to be presented to the sixteenth ordinary annual meeting of the certificate holders, to be held at the offices of the Trust, Winchester House, 50, Old Broad-street, London, on Wednesday, the 11th inst., at one o'clock:—

The revenue for this period, including the balance brought from the previous accounts, viz., £2,140. 10s. 8d., amounted to £16,669. 7s. The Trustees regret that for the first time since the formation of the Trust its revenue should have fallen short of the amount required to pay the half-yearly coupons in full. This is mainly owing to the Anglo-American Telegraph Company, in whose stock the Trust is so largely interested, having paid to its shareholders last year a dividend of only five shillings per cent. It will be observed that, notwithstanding the diminished revenue of the Trust, the return to the certificate holders has been at the rate of 4½ per cent. for the past year. A payment of £2. 10s. was made on account of the coupon due on October 15th, and the balance of 10s. was paid on January 15th. Towards the coupon due on 15th inst., the trustees were only able to pay £1. 10s., leaving a balance of £1. 10s. to be paid as soon as sufficient funds are in hand for the purpose. The expenses of the trust amounted to £1,359. 14s. 10d., and the payments on account of the coupons to £15,214. 10s., together £16,574. 4s. 10d., leaving a balance of £95. 2s. 2d. to be carried forward. The securities held by the trustees remain unchanged. The usual table showing the original and present investments of the Trust follows this report. The meeting will have to elect two auditors for the current year; Mr. John G. Griffiths and Mr. John Gane offers themselves for re-election.

CITY NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 29th ult. amounted to £4,018.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of April was 3,823, estimated to produce £2,900, against 3,964 messages, producing £3,349, in the corresponding month of last year. The traffic receipts for the month of January, estimated at £3,200, realised £3,218.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of April amounted to £1,670, against £1,594 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for April amounted to £43,136, and to £47,611 in the corresponding period of 1886.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company announce the numbers of 264 Five per Cent. Australian Government Subsidy Debentures of £100 each drawn for payment on 1st July next. The traffic receipts for the month of April amounted to £35,955, as compared with £34,292 in the corresponding period of 1886, showing an increase of £1,663.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ended 30th April amounted to £5,250.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 29th ult. were £3,275.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. May 4.		Business Done Week Ending May 4. Highest.	Lowest.
Anglo-American	37,	38	37½	37⅛
Do. Preferred	60½,	61½	60¾	59½
Do. Deferred	15,	16	15⅝	15¼
Brazilian Submarine	10⅝,	10⅞	10⅞	10 11-16
Cuba	12,	12½	12½	—
Do. Preference	18,	19	—	—
Direct Spanish	2¾,	3	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	9,	9½	—	—
Eastern Telegraph	10¾,	11	11	10 11-16
Do. 6 per Cent. Preference	13½,	14	14	—
Do. 5 per Cent. Debentures, 1899	106,	109	108½	107⅝
Eastern Extension	12,	12¼	12 3-16	11 13-16
German Union	10,	10½	10½	—
Globe Telegraph and Trust	5⅝,	5⅞	5⅞	5⅝
Do. Preference	12½,	12¾	12¾	12½
Great Northern	13⅜,	13⅞	13½	—
Indo-European	34,	35	—	—
Reuter's	7½,	8	—	—
Submarine	180,	190	—	—
West India and Panama	⅝,	⅞	—	—
Do. 1st Preference	9¼,	9¾	9½	9⅜
Western Brazilian	7¼,	7½	—	—
Western Union 7 per Cent. 1st Mortgage	120,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¾,	⅞	⅞	-
Oriental	3-16,	5-16	—	—
United Telephone	13,	13½	13 7-16	13⅛

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¾,	3	3	2¾
Do. (fully paid)	4,	4½	—	—
Swan	1⅜,	1⅝	1⅜	—
Maxim Weston	3-16,	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	36,	37	36¾	36
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23¾	23½

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